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EIGHTH

ANNUAL REPORT

OF THE

AGRICULTURAL

EXPERIMENT STATION

OF THE

AGRICULTURAL COLLEGE

OF

MONTANA

FOR THE YEAR ENDING JUNE 30, 1901

BULLETIN NO. 32.

EIGHTH
ANNUAL REPORT
OF THE
AGRICULTURAL
EXPERIMENT STATION
OF THE
AGRICULTURAL COLLEGE
OF
MONTANA

FOR THE YEAR ENDING JUNE 30, 1901

BOZEMAN CHRONICLE PRINT
1902



MONTANA AGRICULTURAL EXPERIMENT STATION

BOZEMAN, MONTANA.

STATE BOARD OF EDUCATION.

JOSEPH K. TOOLE, Governor,	} Ex-Officio.....	Helena
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W. W. WELCH, Supt. of Public Instruction,		
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WALTER S. HARTMAN, President.....	Bozeman
JOHN M. ROBINSON, Vice-President.....	Bozeman
PETER KOCH, Secretary.....	Bozeman
JOSEPH KOUNTZ.....	Bozeman
E. B. LAMME.....	Bozeman

STATION STAFF.

S. FORTIER, Ma. E.....	Director and Irrigation Engineer
F. W. TRAPHAGEN, Ph. D., F. C. S.....	Chemist
ROBT. S. SHAW, B. S. A.....	Agriculturist
J. W. BLANKINSHIP, Ph. D.....	Botanist
R. A. COOLEY, B. Sc.....	Entomologist

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be
addressed to the Director,

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to
any citizen of Montana who sends his name and address to the
Station for that purpose.

REPORT OF THE TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1900-01.

DR.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1901, as per Act of Congress approved March 2, 1887.....\$15,000.00

CR.

By Salaries.....	8,129.38
Labor.....	3,000.00
Publications.....	1,518.31
Postage and stationery.....	171.62
Freight and express.....	286.37
Heat, light, water and power.....	266.45
Chemical supplies.....	89.82
Seeds, plants and sundry supplies.....	477.05
Fertilizers.....	9.50
Feeding stuffs.....	73.47
Library.....	116.25
Tools, implements and machinery.....	422.10
Furniture and fixtures.....	162.50
Scientific apparatus.....	277.18

Total.....\$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1901; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00, and the corresponding disbursements \$15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Attest:

PETER KOCH,
Custodian.

Signed:

JOHN M. ROBINSON,
PETER KOCH,
Auditors.

REPORT OF THE DIRECTOR.

The past year has been one of the most successful in the history of the Experiment Station. The various lines of work that were begun in the past have not only been maintained and their scope and usefulness extended, but new investigations have been undertaken. Each member of the Station Staff has striven to promote the particular industry which he represents, but at the same time there has been a disposition on the part of all to work harmoniously together for the two-fold purpose of benefitting the Montana farmer and building up a great experiment station. The prevailing sentiment among the Station workers is one of confidence in the present, and faith in the future. It is felt that this Experiment Station will soon occupy its rightful place at the head of the Agricultural College and lead the State in all those varied and important industries which are usually grouped under the term of agriculture.

AGRICULTURE IN MONTANA.

It is a great privilege to assist in laying the foundation of what is destined to become the chief source of wealth to many millions of human beings. This State has been one of the last to develop its agricultural resources, but having now made a good start in this direction we believe that few states in the Union will be able to keep pace with it. There are good reasons for such belief. The State is well watered. Under arid conditions the

water supply is of first importance. Such streams as the Yellowstone, Madison, Jefferson and Missoula, the combined summer flow of which would irrigate one and a half million acres, are for the most part unutilized. The native grasses cannot be excelled. When these fail it needs but the thrifty farmer and the irrigation stream to convert the native meadows into productive alfalfa fields. With extensive pasture lands on the mountain slope and alfalfa stacks dotting the valleys, the stockmen should lead every state in the Union. Montana is also admirably adapted to diversified farming. The large yields of vegetables and fruits, grains and fodders that have been harvested for the past few years on the Station farm prove this fact. It will also become in time we believe, one of the leading dairy states. Wisconsin has made wonderful progress in the creamery industry. Last year the value of this product amounted to 22 million dollars. Yet, judged impartially, Montana is capable of surpassing Wisconsin in the production of butter and cheese.

THE WORK OF THE STATION.

Having faith in the agricultural possibilities of Montana the Station officers are endeavoring to so plan and perform their work as to accomplish the most lasting benefits to the people of this State. A skilled mechanic must have tools and appliances before he can perform his allotted task. In like manner the Station scientist needs equipment. Several years have been spent in securing apparatus, fitting up laboratories, making collections and training assistants. This preliminary work is not yet completed, but enough has been done to enable the several departments to do good work along certain lines.

The chemical department is one of the best equipped and the excellent results which it has accomplished have fully justified the expenditure. Most of the knowledge that we now possess of the injurious ingredients in Montana soils, the analysis of potable waters, the adulteration of foods and the excellent quality of the Montana sugar beet has been derived from the Station chemist.

Through the untiring efforts of the agriculturist the Station farm has been transformed from a weed producing tract to a model farm, and his feeding experiments with domestic animals have attracted the attention of all Western stockmen.

The head of the botanical department has spent years of arduous toil in collecting specimens for its herbarium. He has now over 10,000 specimens of neatly mounted plants, forming one of the best collections in the West. During the past year considerable time has been given to injurious weeds and plants poisonous to stock.

The department of entomology was only recently established and in consequence much was required to be done in fitting up a laboratory, indexing the literature pertaining to the subject and making a collection of the insects injurious to the farmer and horticulturist.

The horticultural department is continuing to advance the interests of that important industry. Varieties of all kinds are being tested and those that prove the best are distributed in small lots at low figures among the home-builders of the State.

The poultry buildings and yards are now fairly well equipped and although a comparatively small amount of money has been expended on this industry, the character of the results has been excellent.

Through the liberality of the last State legislature an appropriation of \$2,500 was made to erect and equip a dairy. It is earnestly believed that the State will receive in the years to come one hundred fold from this investment.

In recognition of the fact that the Experiment Station is the only irrigation bureau in Montana the last legislative assembly voted the sum of \$2,000 to be expended in collecting data on irrigation. If one may judge from the nature of the correspondence which reaches this office, the irrigation investigations conducted by the Station have been highly valued by the irrigators of Montana.

CHANGE IN STATION POLICY.

The most important change in the policy of the Station has been made in the interests of the stockmen of the State. The feeding experiments with both sheep and cattle were carried on last winter in car load lots and sold in the principal markets. By this means a larger number of individuals were included in each test, the shrinkage in shipping as well as the actual expenses, selling prices and profits were determined.

The live stock owned by the Station has also been greatly improved. The scrub swine have been sold and replaced by thoroughbreds, the poorest cows have been exchanged for high grades and a sum of money set aside from both the College and Station funds for the purchase of thoroughbred Shorthorns and Herefords, as well as Rambouillet, Lincoln and Shropshire sheep.

The field of investigations has also been broadened. For a number of years nearly all the experiments were conducted either on the Station farm or in the immediate neighborhood. Farmers in other parts of the State formed the opinion that the Montana Experiment Station was established for the sole benefit of Gallatin county and not for the entire State. At the present writing there are over sixty farmers in different sections of Montana co-operating with this Station in the raising of grains, vegetables, legumes and grasses. The work of the chemist, agriculturist, botanist, entomologist and irrigation engineer have also been extended and include, as far as means and opportunity will permit, the entire State.

Greater freedom of action has been accorded the Station officers in performing the work allotted to each but with this privilege has been given greater responsibility. The harmony and good feeling that have prevailed as well as the excellent character of the work performed seem to have shown the wisdom of this change.

STATION STAFF.

With one exception there have been no important changes in the personnel of the Station staff during the year. Mr. S. M. Emery, who occupied the position of director and horticulturist for a number of years, resigned June 30, 1900, and the writer was appointed to succeed him. My term of office, as director, began, therefore, with the fiscal year just closed. In addition to my duties as director I was also placed in charge of the civil engineering course of the College and the irrigation department of the Station. Under such circumstances it was deemed advisable to group the work of the Station into several departments and place a competent Station officer at the head of each. In this way the head of each department could be held directly responsible not only for the character of the investigations conducted under his supervision, but also for the extent and quality of the contributions and publications.

Dr. F. W. Traphagen retained his position as Station chemist and supervised all sugar beet investigations within the State as well as the investigations pertaining to the adulteration of foods which were made in co-operation with the Bureau of Agriculture, Labor and Industry of Montana.

Prof. R. S. Shaw was placed in charge of the Station farm and given the care and management of all live stock. His most important duties were to conduct experiments in grain raising, forage crops and stock feeding.

Dr. J. W. Blankinship continued to act in the capacity of Station botanist and in addition to the labor involved in collecting specimens of the economic plants, investigated the plants poisonous to stock and the injurious weeds of the state.

Prof. R. A. Cooley succeeded himself as entomologist of the Experiment Station and inspector-at-large to the State Horticultural Board.

The horticultural department was placed in direct charge of Mr. Charles Wilson, who was to act under the supervision of the agriculturist and the director.

Mr. H. C. Gardiner was continued in charge of the sub-department of poultry.

All irrigation investigations and water supply measurements were placed under the supervision of the director.

STATION COUNCIL.

The members of the Station staff have held meetings once a month for the purpose of considering matters pertaining to the welfare of the Station. The candid expression of opinions at these meetings on all topics of vital interest has greatly aided the director and executive board to adopt wise measures in regard to plans for future work and the expenditure of Station funds.

NEEDS OF THE STATION.

I desire to call the attention of the members of the governing boards to the urgent needs of the Experiment Station.

In the first place it has no barns, granary or outbuildings worthy of the name. In this respect we rank below every other station in the Union. All our feeding experiments have had to be done under the most laborious and primitive methods. Our agriculturist has done splendid work in raising hundreds of varieties of grains. These have to be stored in log buildings and the mice cause endless trouble in mixing the varieties.

For the past two years the water supply for irrigation has been deficient. During the past season the flow was frequently less than 40 miner's inches for 160 acres of land. An additional supply of at least 25 miner's inches is required. More water is needed for experimental purposes than for ordinary farming.

It would also add greatly to the appearance and utility of the Station farm if a tract of land of about 10 acres, now unoccupied and for sale, located at the northeast corner of the farm could be purchased. In feeding sheep and cattle in car load lots it is difficult to raise enough feed on our limited area and likewise provide experimental tracts for the several departments as well as pasturage for live stock.

The present Station building is over crowded and provision must soon be made for additional class-rooms for farmers' boys who attend during the winter months. More space for laboratories and offices is also needed. The heating plant is now in the

basement of the main building with no facilities for extinguishing fires. There should be a separate heating building.

The Experiment Station should have a skilled veterinarian, thoroughly competent to undertake the bacteriological investigations of animal diseases. The stockmen of the State and the State veterinary surgeon desire it. Dr. M. E. Knowles has rendered valuable services to the State in many ways, but particularly in preventing the spread of animal diseases. The territory is so vast and the number of domestic animals so great that his time is fully occupied in police duties and the identification of diseases. It is of the utmost importance to the stock interests of Montana that this Station supplement the valuable work now done by the State veterinarian.

PUBLICATIONS.

The following bulletins have been published during the year. Of these, numbers 25, 26 and 27 belong to the previous year.

- No. 25. Paris Green and London Purple in Montana, by F. W. Traphagen.
- No. 26. Poultry Raising, by H. C. Gardiner.
- No. 27. Live Stock Feeding Tests, by R. S. Shaw.
- No. 28. Seventh Annual Report.
- No. 29. The Quantity of Water Used in Irrigation, by S. Fortier.
- No. 30. Weeds of Montana, by J. W. Blankinship.
- No. 31. Grazing and Feeding Tests, by R. S. Shaw.

FARMERS' INSTITUTES.

Through the efforts of the friends of agriculture a bill providing for the holding of Farmers' Institutes was passed by the last legislative assembly and received the approval of the Governor March 14, 1901. The Board of Administration consists of the Governor of the State, the presidents of the Montana Wool-Growers' Association, the Montana Live Stock Association and

the Montana Horticultural Society and the director of the Montana Experiment Station. Provision is also made to add the presidents of the dairy and agricultural associations to the board when these latter associations are organized. The Administrative Board is required to meet in November of each year to make the necessary arrangements to hold institutes during the winter months and also in March to arrange for the publication of the proceedings in a Farmers' Institute Annual.

The annual appropriation is \$2,000, but since a large portion of this sum will be expended in reporting and publishing the proceedings the balance will scarcely be sufficient to pay for traveling and incidental expenses.

The members of the Administrative board met in Helena June 10, 1901, and organized by electing A. L. Stone, of Missoula, president and S. Fortier, of Bozeman, secretary. On account of the lack of funds it was decided not to appoint for the present a superintendent of Farmers' Institutes and the secretary was given authority to arrange the dates and places of meeting as well as to secure voluntary speakers for each county institute.

CORRESPONDENCE.

The correspondence of the Station is increasing rapidly. This may be regarded as a true index of the interest that is being taken in experiment station work in Montana. During the year over 2,500 letters have been received and answered. A large number of these came from the rural districts of the State. Many of the letters received from farmers and stock men required considerable time to answer for the reason that there were no Station circulars or bulletins which contained the desired information. As the number of the Station publications increase a greater variety of topics will be discussed and we hope to have in the near future more information to send to our correspondents.

Meanwhile we beg to assure all those who are interested in agricultural pursuits that we will cheerfully do what we can to reply to their enquiries and we hope that the farmers of the State will avail themselves of this opportunity of obtaining such information as this Station can give.

EXCHANGES.

Agricultural Experiments, Minneapolis, Minn.
Agricultural Epitomist, Spencer, Ind.
American Fancier, Johnston, N. Y.
Avant Courier, Bozeman, Mont.
Baltimore Sun, Baltimore, Md.
Belt Valley Times, Belt, Mont.
Big Timber Pioneer, Big Timber, Mont.
Beet Sugar Gazette, Chicago, Ill.
Billings Times, Billings, Mont.
Bozeman Chronicle, Bozeman, Mont.
Butcher's Advocate, Chicago, Ill.
Carbon County Chronicle, Red Lodge, Mont.
Chicago Drover's Journal, Union Stock Yards, Chicago, Ill.
Commercial Poultry Journal, Draper Pub. Co., Chicago Ill.
Dairy and Cream, 315 Dearborn St., Chicago, Ill.
Dillon Tribune, Dillon, Mont.
Elgin Dairy Report, Elgin, Ill.
Farmers' Guide, Huntington, Ind.
Farm Home, Springfield, Ill.
Farm Journal, Philadelphia, Pa.
Farmers' Institute, Chicago, Ill.
Farm News, Springfield, Ohio.
Farmers' Review, Chicago, Ill.
Farm Poultry, Boston, Mass.
Farm Stock and Fireside, Sioux City, Ia.
Farm Stock and Home, Minneapolis, Minn.
Feather, Washington, D. C.
Florist's Review, Chicago, Ill.
Gallatin County Republican, Bozeman, Mont.
Glendive Independent, Glendive, Mont.
Garden and Farm, Chicago, Ill.
Home and Farm, Springfield, Mass.
Home and Garden, St. Paul, Minn.
Horticultural Visitor, Kinmundy, Ill.
Holstein Register, Brattleboro, Vt.
Independent, Helena, Mont.
Inter-Mountain, Butte, Mont.
Industrialist, Manhattan, Kan.
Inter Lake, Kalispell, Mont.
Inland Poultry Journal, Indianapolis, Ind.
Irrigation Age, 916 W. Harrison St., Chicago, Ill.
Jersey Bulletin, Indianapolis, Ind.
Livingston Post, Livingston, Mont.

Madisonian, Virginia City, Mont.
Milwaukee Journal, Milwaukee, Wis.
Mining World, Butte, Mont.
Montana Fruit Grower, Missoula, Mont.
Modern Farmer, St. Joseph, Mo.
National Stockman and Farmer, Chicago, Ill.
Northwestern Poultry and Pets, Spokane, Wash.
Ohio Farmer, Cleveland, Ohio.
Opportunity, St. Paul, Minn.
Orange Judd Farmer, Marquette Building, Chicago, Ill.
Park and Cemetery and Landscape Gardening, Chicago, Ill.
Progressive Farmer, New Port, Va.
Plainsman, Plains, Mont.
Poultry Culture, Kansas City, Mo.
Poultry News, Lincoln, Neb.
Poultry Herald, St. Paul, Minn.
Poultry Journal, Spokane, Wash.
Pacific Poultrymen, Tacoma, Wash.
Rural Spirit, Portland, Ore.
Rural New Yorker, New York, N. Y.
Rural North West, Portland, Ore.
Reliable Poultry Journal, Quincy, Ill.
Stock Growers' Journal, Miles City, Mont.
Strawberry Specialist, Kittrell, N. C.
Stockman and Farmer, Helena, Mont.
Southern Farm Magazine, Baltimore, Md.
Tribune, Stevensville, Mont.
The Weekly Chronicle, San Francisco, Calif.
The Sentinel, Boulder, Mont.
The World, Vancouver, B. C.
Tribune-Review, Butte, Mont.
Tribune, Great Falls, Mont.
Up-to-Date, Indianapolis, Ind.
Western News, Hamilton, Mont.
Wallace Farmer, Des Moines, Ia.
Wisconsin Agriculturist, Racine, Wis.
Western Fruit Grower, St. Joseph, Mo.
West Virginia Farm Review, Charleston, W. Va.
Western Home Journal and Inter-Mountain, Spokane, Wash.

S. FORTIER,
Director.

AGRICULTURAL DEPARTMENT.

R. S. SHAW, Agriculturist.

Throughout this year the work of introducing and testing varieties of grains, grasses, forage and fodder plants and potatoes has been continued. The fourth season's work in the six year crop rotation has also been successfully completed. Much attention has also been given to culture methods relating to their effects on weed destruction and the maintenance of fertility. Some time and money have also been given to permanent improvement work and land reclamation. The greater portion of my time has been spent in the direct supervision of the farm labor, even to the routine work.

VARIETY TESTING OF GRAINS.

Wheats.—Forty-three varieties were grown under irrigation. These consisted of a few new introductions, the balance of which had been grown from one to several years. The number was greatly decreased this year, some twenty-five or more worthless varieties having been discarded. The average yield from these forty-three varieties was 52.6 bushels per acre, and as the result of this season's work in conjunction with the data secured from previous years five selections were made on the basis of quantity and quality of product. These varieties are: Kubanka, Red Fife, Russian 2955, Wild Goose, Wellmans Fife and McKissocks Fife.

Oats.—These included thirty-three varieties chosen and handled in the same way as the wheats. The average yield was 87.9 bushels per acre. Four selections were made, viz.: Poland White, American White, White Wonder and Nameless Beauty. Two varieties chosen the previous year were increased this season to be put in the hands of farmers in various portions of the State, these were the Nameless Beauty and White Russian. From 1.48 acres the former yielded 129.7 bushels, or 87.3 bushels per acre, while the latter yielded 215.8 bushels from 1.96 acres, or 110 bushels per acre. After cleaning and grading, the White Russian oats weighed 44 pounds per measured bushel. Of these two oats, lots not exceeding five bushels were sent out to fifty farmers in different parts of the State. These were cleaned and graded and sold at the rate of \$1.25 per cwt. in response to inquiries for seed. In addition to this smaller trial lots, consisting of a few pounds, were distributed for trial in other locations. From this work we expect to secure returns which will tell us to what extent these varieties have been successful and also where the seed is located.

Barley.—Twenty-four varieties were grown in the same manner as the two preceding grains, giving an average yield of 48.9 bushels per acre. Seven varieties of the brewing kind, imported from Germany, were selected this year. Three kinds of hulless barley, viz.: Black, White and Smooth, selected and increased from previous years, were disposed of to farmers in several sections of the State to be grown for feeding purposes.

Peas.—From some ten or a dozen varieties tested, all have been discarded except two, viz.: Mummy and Canadian Golden Vine. Of these two, the former is a crown pea, an early maturing sort, characterized by a short, strong straw, producing large grain which all ripens at once. The Canadian Golden Vine is an indeterminate grower producing a much longer, more slender and yet heavier yield of straw per acre. These are a later kind. We recommend them where a large quantity of fodder is desired which can be controlled by the water supply. This pea will ripen up and produce an abundance of grain unless grown on moist ground or watered too freely. There has been a greater demand for the seed of these two peas than could be supplied.

Rye.—Some attention has been given to varieties of spring rye with the result that one has been chosen which yields 30.6 bushels per acre and produces a large yield of straw of a fine leafy character.

GRASSES AND FORAGE PLANTS.

Twenty-six grasses have been grown, both with and without irrigation. Though this work is incomplete, and should extend throughout a number of years, some results are being secured as the work progresses. Of the total number, Brome Grass has proved to be the most drouth resistant; it is the first to start in the spring and the last to remain green during the season of drouth, quickly recuperating again in the autumn. It has produced one and one half tons of hay per acre where timothy, under similar conditions with scant soil moisture supply, only produced one half ton to the acre. Many failures to start Brome Grass have been due to the use of poor seed. When the germinating power of the seed is not known it is very difficult to get the right kind of a stand. If the grass comes up too thickly, matting soon results, and the growth becomes fine and spindly. Second in importance, as a drouth resister, followed a native rye grass, but while it possesses these good qualities they are partly offset by a growth somewhat too stemy devoid of leaves. The English and Italian rye grasses were found to be vigorous growers without irrigation, but failed to withstand the severity of the winter. The tenacity of life shown by Blue Grass under these dry conditions was surprising; it makes a remarkable growth early in the season, then dries up and makes a fine nutritious growth in the autumn.

Among the information of practical importance secured in this work was the discovery that the Montana grown grass seeds all possess a remarkably high germinating power, and we believe that the production of grass seeds can be made both practical and profitable.

Of the forage crops Dwarf Essex rape made a remarkably strong growth with one irrigating. It was, however, subject to

attacks from the green aphid which almost totally ruined the rutabaga crop during this same season.

Root Crops.—Of these, mangolds, sugar beets, carrots and rutabagas were grown for feeding purposes. The mangolds gave the largest yield per acre with carrots second and sugar beets third. The rutabagas were almost totally destroyed by the green aphid. These roots were all used for feeding purposes on the farm. The carrots proved to be an excellent food for horses feeding on straw. The mangolds were used for chicken and hog feed and the sugar beets were used exclusively by the hogs. Too much cannot be said in favor of the use of sugar beets for pigs which are being wintered over. They can be fed whole and raw and require little grain along with them to keep the pigs in a thrifty growing condition. From twelve to fifteen tons of sugar beets can be produced from one acre of land at a cost not exceeding \$25.00, if properly handled.

Potatoes.—In all fifty-two varieties were tested. In making selections of the best, most attention was given to those producing the largest percentage of marketable potatoes which was determined after culling out the small and large rough ones. It frequently happens that the sorts producing the greatest total yield per acre do not give the highest percentage of a marketable product. The following selections were made, viz.:

Early Varieties.—Six Weeks Market, Acme, Early Ohio, Early Oxford and Early Vaughan.

Medium Varieties.—Rural New Yorker No. 2, Lees Favorite, Snow Drop, American Wonder and Oregon Pearl.

Late Varieties.—White Maine.

ROTATION TESTS.

During this season the fourth trial of the six year rotation experiment was made, with the following result :

YIELDS OF ROTATION ACRES FOR 1900.

Acre of	<i>Wheat</i> , grain.....	38.3 bu.
" "	" straw.....	3,000 lbs.
" "	<i>Clover</i> , hay.....	3,170 lbs.
" "	<i>Barley</i> , grain.....	87.2 bu.
" "	" straw.....	3,980 lbs.
" "	<i>Sugar Beets</i>	16,310 lbs.
" "	<i>Oats</i> , grain.....	75.5 bu.
" "	" straw.....	2,345 lbs.
" "	<i>Peas</i> , grain.....	37 bu.
" "	" straw.....	

With the exception of the sugar beets this record shows a steady increase in the productiveness of these six acres during the past four years. This season the sugar beet plants were badly damaged soon after coming through the ground as the result of the ravages of a flea beetle. Some fluctuations occur, due to climatic conditions, but in general the yields are satisfactory. While this is the case, however, the rotation is too wide for practicability.

CO-OPERATION WITH FARMERS OF THE STATE.

Because of the great diversity of conditions, it was found necessary to adopt some means by which the work of the Station could be supplemented in as many other portions of the State as possible. In order to accomplish this, small quantities of grains, potatoes etc. were placed in the hands of private individuals for trial. The only conditions required were that accurate reports would be furnished. No less than seventy co-operators were secured. While results have not as yet been obtained from this work we feel that it will be of great benefit to the farmer directly and will bring much valuable information back to the Station which may be used in a practical way.

LIVE STOCK BREEDING AND FEEDING.

Importations of Berkshires and Poland Chinas were made during the year and both herds established with first-class stock to breed from. In all eighteen sales of breeding hogs were made as follows: In Gallatin county 12, Lewis and Clarke 2 and one each in Madison, Cascade, Missoula and Park.

In addition to these, two sales of breeding bucks were also made.

GRAZING AND FEEDING.

Grazing Trials.—In June of 1900, 5.04 acres was fenced off in two equal parts from an alsike field which had been seeded in 1897. The soil consisted of a deep, rich humus, somewhat loamy with a gravelly sub-soil. The two lots were irrigated alternately every two weeks from June 13th to August 18th and pastured in the same way. Twelve yearling Shorthorn and Hereford steers were chosen for the experiment. They were turned on the clover June 9th, remaining until October 1st. It was thought at first that the steers would be sufficient to consume the clover, but on June 18th it was necessary to add to their number to prevent waste. Consequently seven Jersey grade heifers belonging to the Station were turned in upon the clover also. During the experiment one steer died from bloat and all were removed for a few days while the pastures were wet.

On June 9th the twelve steers which were thin from wintering on the range averaged 545 pounds per head, on October 1st the eleven remaining averaged 783 pounds, making an increase of 3,278 pounds which with the gain of 176 pounds made by the steer before death gave a total increase of 3,454 pounds. The Jersey grade heifers, which were one and two years old, weighed 4,575 pounds on June 18th and 5,681 pounds on October 1st, making a total gain of 1,106 pounds. The relative gains were, therefore, for the steers 2.75 pounds per head per day, and for the heifers 1.69 pounds during the same time and under the same conditions.

This tract of 5.04 acres provided food for maintenance and the gains given, for eleven steers during the equivalent of 108 days, and also for the seven heifers 93 days, after taking into consideration the loss of the twelfth steer and the few days the cattle were removed from the pastures.

A sum total of 4,560 pounds animal increase was secured from the 5.04 acres of alsike clover, which amount valued at four cents per pound, gives a cash value of \$182.40, or \$36.19 per acre.

FEEDING STEERS FOR MARKET.

Thirty-one steers were fed for shipment, consisting of the eleven steers used in the grazing test and twenty additional yearlings secured from the range. The feeding began November 13th, 1900, when the steers were divided into three lots according to quality. Those from the clover were fed separately.

The food consumed by the steers from November 13th to March 30th was as follows: Lot I (eleven steers) 37,455 pounds clover and 7,530 pounds barley meal. Lot II (ten steers) 29,335 pounds clover and 7,315 pounds barley meal. Lot III (ten steers) 29,235 pounds clover and 7,308 pounds barley meal. The average daily consumption of food, per capita, during 137 days was, for Lot I, 24.8 pounds clover and 5 pounds barley meal; lot II, 21.4 pounds clover and 5.34 pounds meal; lot III, 21.3 pounds clover and 5.39 pounds meal.

The following gains were made during the 137 day feeding period:

Lot I, eleven steers,	3,015 lbs.	averaging	247.1 lbs.	per capita
“ II, ten	“ 2,410	“	“ 241	“ “ “
“ III, “	“ 2,345	“	“ 234.5	“ “ “

The average daily gains per capita for the three lots throughout the period were 2, 1.75 and 1.71 pounds respectively.

The large gains from such light feeding are attributed to the superior quality of the food and the extremely suitable climatic conditions. The clover had been cured beneath a cloudless sky

and the feeding period consisted of an almost uninterrupted succession of bright still days. The steers were fed in open yards.

We have found with legumes of such quality as can be produced in our valleys that maximum gains can be secured from the use of a minimum amount of grain. Not more than one half pound, per day, per one hundred pounds of live weight is required.

The foods were charged up at \$5.00 per ton for clover and 70 cents per cwt. for barley meal, resulting in a total cost of \$146.34 for lot I, \$124.53 for lot II and \$124.71 for lot III. Therefore from the data given we get the following comparative costs per one hundred pounds increase, viz.: \$4.85, \$5.16 and \$5.31, the cost increasing as the lots lacked in beef type.

These steers were shipped to Seattle, where the sale resulted in a net profit of \$122.59 on the car load, notwithstanding the disadvantage of their age, weight and the heavy shrinkage resulting from the five day trip.

SHEEP FEEDING EXPERIMENTS.

Test No. 1.—Consisted of three lots of lambs of 53 each, receiving the following rations: Pen (1), clover and grain ration of oats and barley; pen (2), clover and screenings; and pen (3), clover only. The relative amounts of food consumed per head per day were: Pen (1), clover 2.9 pounds, grain .56 pounds; pen (2), clover 2.94 pounds and .55 pounds screenings; pen (3), clover 3.32 pounds. The average gains per head per month throughout the 90 days were: Pen (1) 24.96 pounds; pen (2) 28.08 pounds and pen (3) 21.15 pounds. The relative cost of production per 100 pounds was, pen (1) \$4.34, pen (2) \$3.34 and pen (3) \$3.53. We concluded, therefore, that the most profitable results were secured from the clover and screenings because the increase was greater and the cost of production less. Clover was charged at \$5.00 per ton, oats and barley at 85 cents per cwt. and screenings at 55 cents.

CLOVER AND GRAIN HAY COMPARED.

Test No. II.—The same number of lambs was used as in the previous test and under the same conditions. The grain hay consisted of a mixture of oats, peas, barley and spring wheat grown together and cut early in the milk stage. The test was conducted for 60 days and both foods charged up at the price already given for clover.

During these 60 days the clover fed lambs made a gain of 14 pounds per head, while those receiving grain hay gained only 10.68 pounds. The former also produced 100 pounds increase at a cost of \$3.63 as compared with \$4.60 from the grain hay lot. There was too much waste from the grain hay and we believe that horses or cattle could have used this food to better advantage.

EFFECT OF WATER SUPPLY ON FATTENING LAMBS.

Test No. III.—Two lots with food and surrounding conditions alike were treated differently as to water supply. One had constant access to water in the yard, the other was turned to water but once a day. The lambs with constant access to water gained 9.36 pounds each, per month; the others gained but 7.15 pounds in the same time. Those which were permitted to take water at will produced 100 pounds gain at \$3.34 while those with restricted supply cost \$4.51 for the same amount.

CORRESPONDENCE.

The correspondence sent out by me from my department for the year amounted to 442 letters. Many of these were answers to inquiries relating to methods of cultivation, seeding, treating seed grain and requests for information relating to the various kinds of farm products. Many inquiries were also made in regard to live stock and methods of feeding.

PRESS CONTRIBUTIONS.

Seventeen articles were contributed to the local press. These treated of subjects relating directly to the agriculture of Montana and presented in greater part some minor results of Station work not sufficiently important to warrant special publications. Some of the subjects presented were: Sheep Feeding in Montana, Stock Feeding Tests at the Experiment Station, Formalin Treatment for Grain Smuts, Alfalfa for Seed, Co-operation Between the Montana Farmer and the Experiment Station, a series of seven articles on Swine Feeding, Utilizing the Waste Products of Western Farms, etc.

FORMALIN TREATMENT FOR GRAIN SMUTS.

About one year ago reports were sent out from the Experiment Station regarding the use of formalin as a preventive of grain smuts. Since that time another year's experience has been added, verifying the work of the three preceding years.

As requests are coming in daily, asking for instructions as to the use of formalin, we find it necessary to again make our reports far-reaching through the kindness of the press of the State.

Though many different methods of treatment for grain smuts have been devised and tried, none have proven to be more perfect preventatives than formalin. It is pre-eminently a germ destroyer and its work is perfect. It does not in any way injure the vitality of the grain. It is a comparatively inexpensive method and is easily applied.

For oat, barley and wheat smuts a mixture of one pound or pint of formalin to forty gallons of water will be effectual. We have used one pound to thirty-five gallons of water without injury. One pound of formalin used in the proportion given will treat from forty to fifty bushels of grain.

Application.—Either the dipping or sprinkling method may be used with good results and the method chosen will depend upon the facilities at hand for doing the work.

Sprinkling Method.—May be used where floor space or a number of sheets are available. The grain should be spread out thin and the moisture applied with a common watering can, while the grain is being constantly shoveled to insure a thorough application, upon which the effectiveness depends. After a thorough application has been made, the grain should be heaped and allowed to stand for two hours before being spread to dry.

Dipping Method.—This is the most sure as the application is likely to be the most perfect. The sacks containing grain can be immersed in a barrel or trough containing the mixture. The grain should be allowed to remain in the sacks at least two hours before being spread to dry. In both cases the grain should be dried perfectly, except when sown immediately after. In all cases the sacks should be treated. With wheat it is only necessary to wet the outer surface of the grain, but with oats and barley, the application should be made to penetrate the hulls, where spores may have found lodgment. This is accomplished by immersing for a few minutes and then allowing the grain to stand in the sacks as directed, or in a pile if sprinkled.

Formalin has also been successfully used for potato scab by immersing the uncut seed for from one to two hours in a mixture of one pound of formalin to thirty gallons of water.

Formalin is also known as formaldehyde and formic aldehyde. It is a powerful germ destroyer and an extremely active substance. It is sold in the liquid form at about fifty cents per pound and can be secured in most of the drug stores of the State. We cannot urge its use too strongly. Farmers in the vicinity of Bozeman, who have used formalin, report favorably.

WASTE PRODUCTS OF WESTERN FARMS MAY BECOME A SOURCE OF PROFITABLE GAIN THROUGH THE USE OF LIVE STOCK.

After the season of harvest is past, the work of threshing completed and the crops removed for storage or shipment, large quantities of food products still remain on the western farm. While the enormous crops of grain are being secured, there is

always some loss occurring during the process of harvesting, handling and threshing, thus leaving some grain on the fields of even the most careful farmer. These losses are due to the falling of many heads of grain from the sheaf in harvesting or subsequent handling; or, because of their plumpness and weight, some break loose from the stem and are lost; in other cases, again, innumerable grains "shatter out" and fall to the ground as the result of climatic effects peculiar to the arid west. Thus, it follows that much grain remains on the stubble field. It is to these we refer as "waste products," and such they are, unless recovered and converted into a marketable product. And it is through the use of live stock only that they can be turned to profitable account.

In addition to the grains left among the stubble, the meadows or clover fields provide a late growth, which may be used by some kind of stock. Then there are always some weeds and grasses, found bordering along ditches, fences and roads, which can be made use of.

On the majority of western farms no return is secured from these so-called waste materials, except such as is picked up by a few swine on an occasional ranch. The greater portion of this material is, however, generally lost.

In securing lambs, prior to the time of winter feeding, the Montana Experiment Station was enabled to obtain data which gives valuable information relating to the relative capabilities of cattle, sheep and swine, to utilize the waste products of the farm and also the return which could be secured from it.

After the crop had been secured, one hundred and twelve acres of the Station farm became available as a run for stock. This area consisted of stubble from 14 acres of oats, 7 acres wheat, 10 acres barley, 12 acres field and garden peas, 4 acres plat grain, 4 acres grain hay and 4 acres root and potato ground. The balance comprised 57 acres clover stubble, 5 of which had been pastured closely throughout the season and two cuttings removed from the remainder. The barley and wheat stubble grounds both possessed good stands of clover.

On October 4th, 11 yearling steers, 8 Jersey heifers, 3 colts and 25 pigs were given access to the fields. And on October 15th 230 lambs were added. This stock continued on the fields until November 15th.

The 11 yearling steers were put on the fields at a weight of 8,613 pounds, averaging 783 pounds. They were removed to the feed yards on November 15th, weighing 9,060 pounds, with an average of 823. During the 42 days, these steers required 3,344 pounds hay, because of frosts and storm, in addition to the waste materials consumed. Therefore the 447 pounds gain made by the steers, at 4½ cents a pound, is worth \$20.11, which sum, minus the hay consumed, viz.: 3,344 pounds at \$6.00 per ton, gives a profit of \$10.08 gain from the steers, from increase in weight, in addition to food required for maintenance.

The 230 lambs went on the fields on October 15th, weighing 11,699 pounds with an average of 50.86 pounds. On November 15th these were removed to the feed lots, after having weighed 13,948 pounds, averaging 60.64 pounds. We therefore have a total increase of 2,249 pounds of mutton, or 9.78 pounds per head. The increase of 2,249 pounds, at 5 cents, gives a return of \$112.45, minus 1,100 pounds clover hay at \$6.00 per ton, leaving a clear profit of \$109.15 from the lambs consuming waste farm products.

The 24 pigs, consisting of Berkshire and Poland China sows and young stock, were turned on the stubble fields on October 4th. They then gave a total weight of 2,731 pounds, averaging 113.79 pounds, including all ages.

On November 15th, these pigs were prevented from securing further supplies from the fields by severe weather. They were then found to weigh 3,608 pounds, an increase of 877 pounds over the weight at the time of going on the stubble. During this time 410 pounds of barley meal, at 60 cents per cwt., was fed in time of storm, amounting to \$3.28. The 877 pounds gain, at 5¼ cents per pound, gives a return of \$46.04, which sum minus the value of the food fed, amounting to \$3.28, leaves a clear profit of \$42.76 from the 25 pigs while consuming waste grain. And this is, of course, over and above the food required for maintenance.

We regret that data was not secured relating to the colts and and Jersey cattle.

From a financial standpoint, a clear profit of \$161.99 was obtained from the cattle, sheep and swine, as follows: \$109.15 from 230 lambs, \$10.08 from 11 steers and \$42.76 from 25 pigs.

Nor is this all, for no account is made of the value of the waste products secured and used for maintenance of the animals. We have considered only the value of the actual pounds of flesh produced, and have also given credit for the supplementary food used.

Attention is called to the percentage rate of increase, in pounds, of cattle, sheep and swine feeding on waste materials, including the supplementary foods fed. As the original weight of the steers was 3,613 pounds, and 447 pounds increase was made, the percentage rate of increase was 5.19 per cent. The original weight of the lambs being 11,699 pounds, and the increase made 2,249 pounds, the percentage rate of increase was 19.2 per cent. In the case of the swine an increase of 877 pounds was added to the original weight of 2,731 pounds, giving a percentage increase of 32.1 per cent. The 3,344 pounds of hay fed to the 11 steers was just sufficient to supply their needs 12 days out of the 42; the 1,100 pounds of clover fed the 230 lambs during the month was used during a stormy period of 2½ days. The 410 pounds barley meal was required by the pigs during a similar stormy period when they were off the fields. In the case of the lambs the hay fed would not account for more than 100 pounds increase, and the grain fed to the hogs not more than 70 pounds.

These results show conclusively that sheep and pigs, both being close feeders, are better able to recover the waste products of the farm than cattle. And that the three can be used together to best advantage. That under the conditions described, steers are enabled to maintain themselves for a long period, but the gains will not be great. While the pig secures most of the fallen grain, the sheep, with appetite suited to a limitless variety, gleans from all sources alike, securing grain, grass, weeds and late pasture growths.

The sole benefit is not derived entirely from a monetary standpoint, but from the most thorough cleaning which the farm receives, especially from the sheep, which does the work of the scavenger in handsome fashion. They more than pay their way by the weed seeds which they destroy. There are few plants that the sheep will not eat if allowed access to them before they become dead and woody. And any weed seeds consumed by them do not

escape being destroyed. While the pigs secured their food mostly from shattered peas and wheat, the lambs consumed all classes of waste grain and vegetation. During the time the stock was on the fields 55 acres of the tract was plowed, as late as possible, for spring sowing beginning first with those possessing least food.

Where clover can be grown, sheep can be used most advantageously in gathering the waste products of the farm. Coming from the scant range they are thus prepared to go on winter feed in good form. Strange to say, no losses have occurred during two seasons from sheep and lambs grazing on frozen pastures, even though death from bloating has caused serious loss earlier in the season. This experience, with regard to late grazing on clover, is also supported by that of others in the valley. Contrary to eastern experience our clover pastures come out in better form in the spring when grazed off late in the fall. Luxuriant growths remaining on the fields seem to cause smothering or winter killing. The fields are also benefitted by the return of much fertilizing material.

As the result of utilizing the "waste products" of 112 acres on a Montana farm, by the means of live stock, we have a clear profit of \$161.99 or \$1.44 per acre over and above the value of the food secured by the animals and required for maintenance. And And these profits resulted practically without any expenditure for labor. If all the waste products of western farms were thus utilized they would become a source of revenue of great magnitude. The best financial successes result from securing all the revenue obtainable from these apparently worthless and insignificant sources.

FATTENING LAMBS ON CLOVER IN GALLATIN VALLEY.

The Gallatin valley has long been famous for the production of brewing barley, wheat and oats, of unsurpassed quality. The conditions giving rise to such favorable results have been known to find their source in a deep, rich, easily worked soil, with an abundance of water for irrigation, and climatic conditions which

bring all the forces of nature into harmony in the perfect development of these products. But while the production of these grains is unsurpassed, both in quantity and quality, the same conditions which favor their growth produces marvelous results in the production of clover. As the result of experiments along this line, the Experiment Station has secured much valuable data relating to the growth of clover, its effect on the fertility of the land, and utility as a food factor. These facts will appear in future publications. And while the Station most earnestly advocates the growth of clover in Gallatin valley, the constantly increasing area has lead to another important question, viz: The most economic use which can be made of clover in order to secure the greatest possible return from it.

Two years ago experiments were conducted in lamb feeding, in which alsike, red clover, and alfalfa were the chief foods used. Careful comparison showed these three to possess feeding value in the order named, though with slight differences in any case. So that, what hereinafter is said of red clover, and its feeding value will apply much the same to alsike and alfalfa. During the last winter season, comparative results were obtained from the fattening of lambs on clover alone, with those receiving both clover and grain. These results have been so satisfactory, both by way of quantity and quality of product and financial return, that as the harvest season of 1900 closes, with innumerable clover stacks dotting the valley, we feel that the results of our work may at least offer some suggestions regarding the use of clover in mutton production.

On December 12th, 1899, 60 lambs were started on a 90 day feeding test. These were divided into three lots of 20 each; lot (1) received clover and wheat, lot (2) clover only, and lot (3) clover and oats. Within this period of 90 days, the lambs feeding on clover alone, consumed an average amount of 3.16 pounds per head, per day. The two lots receiving an average of .93 pounds wheat and oats respectively per head each day, consumed only 2.14 pounds clover.

The gains made during the 90 days were as follows: Lot (1), fed clover and wheat, 30 pounds each; lot (2), clover only, 24.3 pounds; lot (3), clover and oats, 31.75 pounds each. Considering

the fact that nearly a pound of grain was fed to each lamb, per day, to two of the lots, the showing made by clover alone is remarkably good. With lambs of the range type, feeders seldom reach a gain of ten pounds per head, per month, when both hay and grain are used. The two lots receiving grain and clover also had a slight advantage from the use of a small allowance of roots.

Cost of Feeding.—The clover hay was charged up at \$6.00 per ton, damaged wheat at 40 cents per cwt., and oats at 90 cents per cwt. At this rate the cost of food for each of the three pens of 20 each, for 90 days, was as follows: Lot (1), clover and wheat, \$19.38; lot (2), clover only, \$17.21; lot (3), clover and oats, \$27.95. The total gains per ton, in order, above given, were: Lot (1), 601 pounds; lot (2), 486 pounds; and lot (3), 635 pounds. Considering these gains, and the cost of foods, the clover and wheat ration produced mutton at a cost of \$3.22 per cwt. increase, clover alone \$3.54, and the clover and oats \$4.30. These results show conclusively that, though clover alone did not give absolutely the most rapid or cheapest increase, still, there was little difference between it and the clover and wheat ration, and that satisfactory gains and financial returns can be obtained from the clover alone. They also show that oats at the price charged, cannot be profitably used except in small quantities.

The profits derived from these three methods of feeding, at the end of 90 days, were:

Net profit per head, from lambs fed clover and wheat..	96 cts.
“ “ “ “ “ “ “ “ only.....	82 “
“ “ “ “ “ “ “ “ and oats.....	62 “

The lambs were bought at \$3.00 each and sold at the rate of \$4.68 per cwt., live weight. We conclude from the results of No. 1, that cheap grains, otherwise unsalable, can be used to good advantage along with clover for fattening lambs, and also, that while the clover alone gave good results, we believe that where possible a small amount of grain fed with it, will increase the gain and add to the quality, but large quantities are not necessary with the quality of clover here produced. From the data obtained it was found that 11.8 pounds of clover was required to maintain the animal and produce a pound of gain. Thus one ton of clover produced 169.5 pounds of mutton, which, at the selling price of

\$4.68 per cwt. was worth \$7.93. Is this not a good market value for one ton of clover hay? Is it possible to dispose of it to better advantage in any other way?

The necessity of securing the proper type of lambs for feeding is very important. During the past two seasons, comparative results have been secured by feeding lambs of the mutton type, and wool producing kind by similar methods. Those of the mutton type used, contained a large percentage of Shropshire blood. They were large framed and strong boned, cylindrical of form, possessing broad evenly fleshed backs, with good width at brisket, chest, and shoulders. The other class, composed of Merino grades, were almost the reverse as to general form and quality. The compact lamb, of the former class, carrying a large quantity of natural flesh, when fed on an expensive ration of clover and oats, produced 100 pounds gain at a cost of \$4.39 per cwt., while those of the inferior type, using the same kind of food, in the same amount, cost \$4.65 per cwt. increase. The lambs of the mutton type required over one-half pound less clover to each pound of increase.

The results obtained lead us to conclude that, with the conditions which Gallatin valley presents, the possibilities for mutton production are unparalleled, for in the first place, the best foods can be grown abundantly, and secondly, we have the stock near at hand to consume it. Individual acres of clover, grown at the Experiment Station, for three successive years produced over one and one-half tons of hay, at from 119 to 133 days from date of sowing.

During the season just closed, a field of 7.26 acres produced, at two cuttings, a total of 35 tons 1,451 pounds of well cured clover hay. And while this food can be produced in such great abundance, it has the advantage of possessing a large percentage of those nitrogenous compounds or flesh formers which the eastern feeder, who relies chiefly on corn or screenings, cannot buy. The clover produces a much better quality of meat than the starchy foods, such as screenings, corn, barley, etc., and this will apply to beef and dairy productions as well.

While the production of clover, and its conversion into mutton is desirable, this need not interfere with the grain output. On the contrary, clover must materially assist the grain producer, taking

the place, as it is, of the vast summer fallow area. We therefore have the clover for feeding purposes without decreasing the grain area.

The question of the disposal of finished mutton is one which confronts us in a serious way, as the local demand does not require but a limited quantity. It is the purpose of the Experiment Station to fatten a car load each of lambs and steers, for shipment to Chicago in the early spring. Several others have also signified their intention of feeding in time to join this experimental shipment. We have found that it will pay to feed lambs from 70 to 90 days and steers at least 120.

Results justify conclusions to the effect that mutton can be successfully produced on clover alone, though the use of a small grain allowance is desirable especially because of its ultimate effect on quality. Where clover or alfalfa may have been damaged and unsaleable, it cannot be used in a better way than as a sheep food. We cannot urge too strongly the growth of clover in Gallatin valley and its subsequent conversion into mutton.

What has been said of the clover and Gallatin valley conditions, will apply in much the same way to the numerous alfalfa regions of Montana.

CHEMICAL DEPARTMENT.

F. W. TRAPHAGEN, Chemist.

The usual lines of work have been carried on by this department during the past twelve months. A considerable amount of time was given to an examination of the condition of the foods found in our market and a resume of the results is introduced here. A detailed report of this work has been published in the Biennial Report of the Bureau of Agriculture, Labor and Industry.

Much interest has been manifested in this work and numerous newspaper articles have been written, and addresses given in an effort to better conditions by arousing public sentiment and securing the enactment of proper legislation for the protection of our citizens. Through the efforts of Senator Hoffman a bill was introduced into the legislature at its last session and its passage through the Senate secured. The activity of a lobby of grocers, mainly from Butte, caused the defeat of the bill in the House of Representatives, not, however, without the disapproval of a large number of our best citizens.

It is to be hoped that funds will be found for the purchase of another series of samples to be used as an object lesson in another campaign for protection.

RESULTS OF FOOD EXAMINATION.

	Found Adulterated.	Not Found Adulterated.
Canned Vegetables.....	6	25
Soups.....	5	9
Tomato Catsups.....	12	0
Jams, Jellies and Preserves.....	26	0
Cereal Breakfast Foods.....	0	30
Baking Powders.....	9	6
Flour.....	0	18
Miscellaneous Foods.....	15	13
Vinegars.....	21	6

The sugar beet investigations of the past season have not been at all satisfactory. Because of changes in the administration of this part of our work, seed was not sent out sufficiently early to secure active co-operation on the part of our farmers and very few reported having planted.

This season we have projected the most general test yet carried on, and every agricultural section of the State will be represented in the trials. The seed has been sent out sufficiently early to secure the benefit of planting as soon as conditions permit and the results should be of considerable value.

On the Bitter Root Stock Farm, near Hamilton, Mont., the most systematic series of experiments, yet made within the State, are being carried on. Small tracts selected at different points on the farm have been chosen, affording a great variety of soil and conditions. Sugar beets are being grown on these plats under the direction of a skilled sugar beet culturist from Utah, and will be handled far better than they ever have been in this State. Heretofore the crop has been grown incidentally, usually merely as a favor to the Experiment Station, and has received attention when everything else has been looked after. While we greatly appreciate the assistance we have received from co-operating farmers, it is no less true that sugar beets have been greatly neglected in the past and the excellent results previously obtained have been in spite of very unfavorable conditions.

Besides the tests above mentioned, through the efforts of Hon. W. A. Clark, seed has been widely distributed throughout the valley of Clark's Fork of the Yellowstone river, and a new field will be studied here. There is little doubt that, if the results of the present season are satisfactory, a beet sugar factory will be established at some point within the State. This means much, not only to the favored community, but to the State at large.

In connection with our study of the alkali problem we have been making a series of experiments to determine the limit of tolerance for alkali of our different crops. These tests have been very satisfactory and serve to show that there are very few places in our State where the alkali alone is in sufficient quantity to prohibit the growth of our usual crops. A number of interesting points have been noted in this investigation, which will be pre-

sented in a bulletin soon to be issued. Successive series of experiments have been planned with various plants, which, taken in connection with our analysis of the soil of different sections, will enable us to prescribe the crop most likely to succeed in any instance.

Pot experiments have been instituted to determine the best methods of handling such soils as resist ordinary methods of treatment. The effects of tailings and tailings waters from the copper smelters, upon hay and grain crops, have been carefully studied and the results will be embodied in a bulletin to be issued soon. It may be said that the conclusion was reached that chemically there has no evil resulted from the presence of metals in solution and that the mechanical effects are the same as would come from the presence of the same amount of sand or clay under similar conditions.

A resume of the analytical work shows the following as the work of the year:

Soils.....	285
Foods.....	201
Water.....	10
Milk, etc.....	4
Butter.....	12
Beets.....	7
Coal.....	8
Miscellaneous.....	36
Total.	563

BOTANICAL DEPARTMENT.

J. W. BLANKINSHIP, Botanist.

The work of the botanist during the past year has been confined chiefly to a study of the weeds of the State and the preparation of a summary of our knowledge of the same, issued as Bulletin No. 30 of this Station, and a continuation of the study of the plants poisonous to stock and the conditions under which that poisoning usually occurs. Unfortunately the field work could not begin until June 1, after the main period of poisoning was over; so that relatively few cases could be investigated immediately after the poisoning occurred. Nevertheless, through the co-operation of the various railways traversing the State, a large amount of data was accumulated and the distribution of the plants chiefly concerned was largely determined.

In addition to this work a considerable number of plants sent in for identification have been determined and more than a thousand specimens have been added to the herbarium, among which was a set of the grasses of the United States from the Division of Agrostology at Washington.

A NATIVE HEDGE PLANT.

Hedges are desirable in every country not only for their permanent utility in fencing yards and fields, but also for their ornamental value. As yet no plant has come into general use in Montana for this purpose, but a series of independent experiments

have been made in various parts of the State to utilize the buffalo-berry shrub (*Shepherdia argentea*, Nutt.) for this purpose, and, while not fully successful, the results seem to show that with proper care the plant can probably be made to answer the purpose.

Shepherdia argentea, Nutt. grows in the lowlands along streams throughout the Great Plains region from Manitoba and Kansas westward to the mountains and in the Great Basin to the Sierra Nevada range. In Montana it is found in more or less abundance east of the Divide, along the Missouri, Yellowstone and their tributaries, often forming dense impenetrable thickets in the lowlands. It is a shrub, or small tree, rarely exceeding 25 feet in height and a diameter of 5 or 6 inches, with widely spreading, tough and thorny branches and bearing a dense cluster of pale red, rarely yellow, berries, ripening in autumn and having a sharp acid flavor, esteemed for jelly-making, for which they are extensively used.

Although the plants grow naturally only in the low ground, there is no reason why they should not be made to grow wherever the roots can be kept moist by irrigation in the plains or valleys in any part of the State. The following gentlemen give the results of their experiments with the buffalo-berry plant for the benefit of others who may care to continue the work.

Mr. John Matheson, living 8 miles east of Chinook in the Milk river valley, writes (December 21, 1900) as follows:

"The buffalo-bush hedge was planted three years ago as an experiment and seems to answer the purpose. It grows in alkali land, stands the climate and bears trimming. It is not a very fast grower and it will take about 6 years before it can be depended on for a fence. I tried to grow the plants from the seed, but failed, owing to the place being flooded in the spring. The plants should be reset, when not more than six inches high, in a double row about twelve inches apart each way. The cost of such a fence will not exceed 50 cents a rod. The Osage orange will not grow; I tried it and failed."

Mr. Olney Taylor, of the State Board of Horticulture, has performed a similar experiment at Park City on the Yellowstone and gives his conclusions (November 12, 1901) as below:

"In regard to the buffalo-berry as a hedge plant I will say that my experience with it is rather limited. A few years ago I planted some seeds along the road, which grew well and, if they had been properly pruned, I think would have made a good hedge, but they have been allowed to grow naturally and are tall and not as thick as they should be. The greatest objection I have to them is that they sprout quite badly where the ground is cultivated near them."

Mr. A. M. Crawford, of Billings, is another who has tried the plant for this purpose and writes under date of November 13, 1901:

"The buffalo-berry makes a beautiful and effective hedge. The land should be in good tillable condition before planting. If new ground, a strip about four furrows wide and two furrows deep—as deep as the plow can be made to run—should be prepared in the fall for early spring planting. While the buffalo-berry is native along our river bottoms, I find that the young plants can be readily established on uplands, but with difficulty on low, soggy ground; and that, while in the former position they must be carefully irrigated, in the latter they are likely to get in a way troublesome brush. One more weaving and you have a hedge that cattle, and even boys, are willing to let alone. From this time on it is a question of neatness and the pruning shears. The work of weaving can be greatly facilitated by having smooth wires at stated intervals under which to bend the young wood."

The buffalo-berry will not grow in the foothills above 3,000 feet altitude, but it may be possible to utilize the black and red haw (*Crataegus coccinea*, L. and *C. Douglasii*, Lindl.), which take its place in those situations and grow in abundance. For ornamental hedges the barberry (*Berberis Canadensis*, Pursh and *B. vulgaris*, L.) and the privet (*Ligustrum vulgare*, L.) may well be employed as they are perfectly hardy in most situations below 5,000 feet and have been grown successfully in the gardens of the Station at almost that altitude.

THE "ARCTIC BERRY" FRAUD.

For a number of years a man, with a camping outfit, has been canvassing various parts of the State selling a so-called "Arctic berry," taking orders throughout a particular section during the spring and summer and delivering the plants in the fall. He exhibits a number of the "berries" preserved in a liquid in a bottle and they are said to have a very attractive appearance, being "three times the size of a strawberry and with the color of an orange." He claims the fruit is of his own production, resulting from crosses between a number of berries of which the huckleberry, sarvice berry, strawberry, wild cherry and several other unnamed species, play a part, the whole combining to form the wonderful fruit then exhibited. He claims the fruit was first grown by himself in Idaho, and is now cultivated successfully in the Gallatin valley, near Bozeman. From reports it seems that this plausible gentleman has "worked" a great part of the State, including the region about Great Falls, the Gallatin valley and the Madison river and spent the summer of 1901 in Sweet Grass and Carbon counties. The matter was called to the attention of the Station in time to advertise the fraud in the newspapers before the delivery of the "berries" and relatively few were disposed of. It was then stated that any man knowingly making such statements as those attributed to him in regard to the origin of the fruit in question, was a fraud and subject to prosecution under the laws of the State, and he was asked to submit some of the fruit and plants to this Station that we might pass upon the value of this remarkable hybrid. Notice was also given in all the Bozeman papers for information in regard to this new plant, from anyone cultivating it in this vicinity, but no responses have been received either from the agent or from any successful grower, for all the plants sold in this vicinity are either dead or killed down each year by the frost, and we have yet been unable to secure living specimens for examination. Horticulturists, who have seen the growing "Arctic berry," report the plant sold as the white mulberry (*Morus alba*, L.) and some leaf-scrap examined seem to agree with that species. The thing is a palpable fake, for such crosses as those mentioned

are botanically impossible. Space is here given the subject in order to protect the people of the State from such imposition hereafter, and to warn our neighbors of adjoining States to look out for this smooth-tongued "nurseryman."

POSSIBILITIES OF STRAWBERRY CULTURE IN THE STATE.

In a state with great variations in climate, due to the difference in altitude found in mountainous regions, it is possible to extend the fruiting period of seasonal fruits, such as the strawberry, over considerable time by taking advantage of this progress of season at the different altitudes, and this fruiting period may be still further extended by planting early and late varieties. As far as can be yet judged by the native vegetation, there appears to be a difference of about a week in the opening of flowers and the ripening of fruit for each 2,000 feet of altitude and as our altitude ranges from about 1,800 to over 11,000 feet, it seems that advantage might be profitably taken of this fact for growing a fruit for which there is always a ready market.

THE ALKALI DISEASE OF PLANTS.

Several times recently my attention has been called to a supposed parasitic disease affecting plants in certain localities, but upon examination no fungus was found, but the plants had every indication of poisoning by alkali, either through the rise and settling in low ground of the waters of irrigation containing these salts in excess, or through watering potted plants with such water. In general, plants thus affected show it by the gradual yellowing of the foliage, or by the withering of the leaves at tips and edges, until they die and drop off, causing the death of the plant. A considerable number of the trees in the park along the river side, at Great Falls, appear to have died from this cause and the same trouble has been found with shade trees in certain localities at Helena and Bozeman. The remedy in such cases is clearly

underground drainage to carry off the excess of salts accumulating in the water in such situations, or a reduction in the irrigation on the higher ground near by. The trouble seems also to affect potted plants and gardens, when watered with water containing an excess of alkali, and cases have arisen seemingly from this cause at Columbia Falls and Helena and will doubtless be noted from other localities in the eastern part of the State, the remedy here being to secure water from some source not thus contaminated.

The effects of alkali upon plants are thus described by Dr. E. W. Hilgard, director of the California Experiment Station: "In the case of herbaceous plants the first effect is a dwarfing of the whole system, and as the salts accumulate at the surface, they will cause a corrosion of the root-crown. In the case of trees also the root-crown usually shows a darkening of the bark, and a browning of the liber, if the alkali is strong enough. It is then that the leaves yellow, but short of such an effect upon the root-crown the essential symptom of alkalied plants is a dwarfing."

INVESTIGATIONS OF PLANTS POISONOUS TO STOCK IN MONTANA.

This work, begun during the preceding summer has been continued for most of the present season, but has been confined mainly to field work to determine the plants causing the various cases of poisoning reported, the times of the year when such poisoning is most apt to occur with the conditions then prevailing and the localities in the State found to be most dangerous to stock, with the reasons therefor; also, to determine the distribution over the State of the plants known or suspected of causing this poisoning and to devise methods for avoiding the same, as far as possible. The work of experimentation to ascertain the exact effects of suspected plants upon animals has been left, by agreement, to the specialists of the Department of Agriculture, who are conducting their work at this Station during the present summer.

In order to call the attention of stockmen to this work and secure their assistance in conducting the same, the following circular was issued:

NOTICE TO STOCKMEN.

The Montana Agricultural Experiment Station in co-operation with the Department of Agriculture at Washington and the State Veterinarian at Helena, is attempting during the present season to make a study of the plants poisonous to stock in this state. In order to fully determine the conditions under which the poisoning normally occurs and the plants to which it may be referred, it is desired that detailed reports be made to this Station of losses now occurring, as well as any losses which may have occurred in the past, noting, as far as practicable, (1) the exact locality in the State in which such poisoning occurred and the local conditions, whether lowland or upland, plains, foothills or mountains, about springs or along streams; (2) the time of the year of such poisoning; (3) stock affected, whether horses, cattle or sheep; (4) the number poisoned, their symptoms and treatment pursued, as well as relative proportion of deaths; and (5) the plants suspected, with descriptions or specimens. It is only by the compilation of such data that the dangerous zones in the State can be accurately determined, as well as the time when they must be avoided.

By the co-operation of the stockmen of the State in this work, particularly in reporting promptly for investigation, all new cases of poisoning that may occur, it is hoped that definite results may be secured and the present loss due to this cause prevented.

Address all communications and specimens to, MONTANA AGRICULTURAL EXPERIMENT STATION, Bozeman, Montana.

June 5, 1901.

The results of this investigation will be issued as a bulletin early next spring in time to be of service to the stockmen during the dangerous season.

In order to make this work as practical as possible, the Station has had sets of the plants, suspected or known to be poisonous, mounted and framed for general distribution in the principal stock-growing centers and these will be sent to anyone who will pay the expense of framing and transportation and agree to place them on exhibition in some public place in his locality. A number of these frames have already been distributed. It is hoped that next season portfolios can be prepared of the most dangerous species for distribution to stockmen to be placed in the hands of their foremen and herders to make known the plants, which must be avoided or destroyed, but at present not enough specimens have been collected to enable this to be done, except in a few cases.

ENTOMOLOGICAL DEPARTMENT.

R. A. COOLEY, Entomologist.

An account of five insect pests, not previously mentioned in the publications of this Experiment Station as being present in Montana, is herewith presented. All are of first-class importance, some having proved themselves very injurious to our vegetation and the others being well known for their destructive habits elsewhere.

The year's experience has emphasized the importance of the entomologist's being about the State as much as possible in order that the presence of injurious insects may be detected and made known. The widespread belief in Montana that injurious insects have not yet found their way to our fields is only partially based on facts, but is due, rather, to a lack of knowledge of the real conditions. It seems clear, then, that the actual conditions should be published as rapidly as possible so that the fruit grower and rancher may not, through ignorance of their presence, allow them to gain a foothold. The past year has developed a knowledge of the presence and distribution of a considerable number of very important pests and there can be no doubt that the coming year will reveal many more.

THE STRAWBERRY LEAF-ROLLER.

Phoxopteris comptana. Frol.

So far as is known to the writer the strawberry leaf-roller has not yet been very destructive in Montana, but for many years the species has been fairly well known in other parts of the country and in some localities has been exceedingly destructive. In Washington it is looked upon as being the most destructive pest affecting the strawberry in that state. We therefore have reason to fear that in a few years we too may suffer from its ravages. It has been discovered in Helena, and has been reported from Miles City.

The insect feeds upon strawberry, blackberry, raspberry and various other plants.

It receives its name from its habit of rolling and crumpling the leaves of its host-plant. The larva, which is small and of a greenish color, lives within the rolled or crumpled leaves where it feeds from the inside. When abundant, the larvae not only devour the foliage but cause it to turn brown. They are very active and when taken into one's hands will quickly wriggle out and drop to the ground. There are two broods of the larvae each year, the first brood appearing in June and the second in August. The parent moths are very small and of a reddish brown color.

The best remedy to be employed is to cut the vines after harvesting the crop, and, after allowing them to dry burn them as they lie. If there are not enough vines to burn well some old hay or straw may first be spread over the field. No harm will be done to the vines by burning in this way.

If it is preferred the vines may be sprayed after harvesting the crop. The insecticide used should be arsenate of lead in preference to Paris green since it remains on the foliage very much longer. This insecticide has a distinct advantage for this pest since, remaining so persistently on the foliage, will be rolled by larvae into the leaves where it is needed.

THE NATIVE CURRANT SAW-FLY.

Gymnonychus appendiculatus. Hartig.

This insect was very destructive to gooseberries and currants during the year in the vicinity of Kalispell, showing preference for the first named fruit but entirely defoliating currants also. The species also occurs in Miles City and like many other pests probably exists unrecorded in other parts of the State.

The larvae are pale green even when full grown and lack the black spots found on the larvae of the European relative of similar habits, which is very common in the United States.

The adults are four-winged fly-like insects, black in color with yellow markings. Two broods of the larvae occur, one appearing late in June or early in July and one in August.

White hellebore, either dusted on the foliage while the latter is damp, or sprayed in water at the rate of one pound in twenty-five gallons, is a good remedy.

The hellebore should be secured in advance since when needed it may not be found in sufficient quantity.

THE CABBAGE LEAF-MINER.

Plutella cruciferarum. Zell.

The cabbage leaf-miner is a European pest which has been imported into this country and has become widely distributed. In Montana it is known by the writer to occur at Hamilton, Bozeman, Missoula and Miles City. It has doubtless been brought into the State on cabbage heads intended for consumption.

The species occurs on the leaves of cabbage and related plants as small green worms, one-fourth of an inch long, tapering toward both ends and having the head yellowish. When ready to transform the larva spins a delicate gauze-like cocoon of white silken threads and the enclosed pupa may be readily seen through the silken case. The moth is about three-quarters of an inch long,

with gray, white, black and brown markings. Three diamond shaped spots on the back of this long, slender and shy moth make it easily recognized.

Spraying the affected plants with water is said to be a good remedy. The insect thrives only in dry weather. Pyrethrum insect powder has given satisfactory results. The larvae often co-exist with the cabbage aphis, discussed below, and are readily destroyed by the substances used in controlling that pest.

THE CABBAGE APHIS.

Aphis brassicae. Linn.

A great many fields of cabbage and related plants were wholly or partly destroyed during the year by this species and a large number of letters concerning it were received and answered. The insects were present in almost incredible numbers completely covering all parts of the plants and working into the heads of cauliflower in such numbers as to destroy their value. Affected plants withered and appeared as if suffering from dry weather.

The real color of the lice is greenish gray, but this is obscured by the waxy or mealy secretion which covers their bodies and gives them a leaden color.

The species attacks cabbage, turnip, cauliflower, rape and other plants of the same natural family (*Cruciferae*).

As a remedy for the pest, kerosene emulsion, one part of the emulsion in ten of water, or whale-oil (more correctly fish-oil) soap one pound in fourteen gallons of water, may be used.

The insects readily succumb to these substances, the only difficulty in the treatment being to get the insecticide in contact with all the lice.

The lice cover both surfaces of the leaves thereby making it necessary to spray the under as well as the upper surface. The spray-nozzle must be lowered among and under the leaves. It may, if desired, be fastened to the end of a piece of half-inch tubing which will allow the operator to stand erect.

THE ROSE CURCULIO.

Rhynchites bicolor. Fab.

This insect is generally distributed throughout the United States and while having been seen by the writer only at Bozeman, Missoula, Hamilton and Kalispell, in Montana, it is almost certain that it occurs in all parts of the State.

The rose curculio is a beetle one-fourth of an inch long, red over the entire upper surface from the head to the tip of the abdomen, with the ventral surface, beak or snout, antennæ and legs black.

It affects both wild and cultivated roses, boring by means of its long snout into the buds and cutting the stems causing the buds to lop. It is particularly destructive west of the range where roses are grown more readily than on the east side.

Great injury to roses is caused by this species. It takes very much the same place that the rose chafer (*Macrodactylus subspinosus*) occupies in the east.

No very satisfactory remedy is known. The writer is making observations on the habits of the species and hopes to find some means of defense against it.

Temporary relief may be secured by hand picking or by drumming them off into a pan of kerosene, or kerosene and water.

SUB-DEPARTMENT OF POULTRY.

H. C. GARDINER.

Student in Charge.

During September, October, November and December 1900 three pens of fowl were fed separately, with a view to determine the best method of feeding and caring for hens during the moulting period. While this work was not carried far enough for conclusive results, we would from the results obtained, advise a liberal ration for moulting hens, and attention early in the fall. It was found that flax seed was a valuable addition to the ration, and that a full ration tended to stimulate the growth of feathers.

Although we must depend chiefly upon early hatched pullets for winter eggs, still it is an additional source of profit if the year old and two year old hens can be made to contribute their share to the egg-basket. In order to secure these results fowls must be fed liberally commencing in September, in order to hasten the moulting of those who have begun, and to start those whose low condition, resulting either from rearing a brood of chicks, or laying late in the summer, has left them without vigor enough to moult before cold weather. Owing to this general low condition which follows the summer's work the flock may not respond readily to their feed, and it is advisable to stimulate and tone the digestive system with Cayenne pepper, assafoetida, etc., and give "Douglas mixture" in their drinking water twice a week. Douglas mixture consists of four ounces copperas, one ounce sulphuric acid in two gallons of water, using it in the proportion of a tablespoon in a quart of drinking water twice a week. Such precautions will to a great extent fortify the bird's system against roup and colds which occur so generally in this State in the fall and winter months.

During the past year we have received many inquiries about how to treat flocks which are affected with roup and colds, and we have advised maintaining all stock in a vigorous condition in order that they may successfully withstand our broken fall and

winter weather. Debilitated animals are the most susceptible to diseases of any kind, and improper quarters and poor feed only add to the danger. In order to secure freedom from roup the houses must be dry, free from draft, of reasonably even temperature and well ventilated. Frame houses are best because they are easily kept dry, and we believe that it is a mistake to construct poultry houses of stone or concrete, as the walls of such buildings are almost invariably damp, and fowls kept in such buildings are particularly liable to disease. In order to maintain an even temperature all chinks and cracks should be kept closed and the building made as tight as possible, with a window space of about one-eighth of the front in a building six feet high. Too large an area of glass causes the building to heat very quickly during the middle of the day, while at night it affords a large radiating surface, chilling the interior and producing catarrh and colds among the inmates. This difficulty may be overcome best, by the proper glass area, and by the use of a stove on cold nights and during long cloudy spells. Last, but not least, comes the ventilation question, while a building should be built as nearly air tight as possible, it should also be well ventilated. Nothing poisons the animal system more quickly than impure air laden with gases exhaled by the fowl, and arising from the droppings. These gases being naturally heavier than the air settle in the lower portions of the house, and it is from these lower levels we must ventilate. Ventilators opening at the roof are inefficient; while they may remove a portion of the lower body of air, they remove chiefly the upper portion which is warm and pure and which should be retained. To thoroughly, cheaply and easily ventilate, run a common six-inch stove pipe from the roof to within six inches of the floor, having a damper in it at a convenient height. The warm air near the roof warms this pipe, which in turn warms the air inside, and this enclosed air rising creates a draft which gradually and successfully removes the impure air in the vicinity of the fowl. We believe if the many inquirers and others, whose flocks are affected, would follow these directions, this disease which is so prevalent throughout the State would soon become checked.

During January, February and March another feeding experiment was conducted in which six pens, comprising 90 birds in all,

were fed to determine the feeding value of three of our most widely grown grains, wheat, oats and barley, and further what advantage is to be gained from mixed grain rations. Although this work will be continued further before any definite conclusions are drawn we believe that oats and wheat is the most profitable mixture and wheat is the most desirable to feed alone.

The department also published a bulletin designed to meet the needs of beginners in this branch of farming, which discussed the following topics: Breeds of poultry best suited to Montana's market and climatic conditions, artificial incubation and the care of incubator chicks, general management of breeding stock and laying birds, advantages of pure-bred stock, construction and ventilation of buildings, construction of brooders and brood coops, incubator oils, and egg-preservation. The results of feeding experiments which were planned to show the necessity of variety rations in egg production were also given, together with data relative to the effect of these different rations upon egg fertility, and upon the composition of the egg.

During the winter months we were forced to keep several of the pens confined on account of lack of yards, the ground about the building being only partially graded. We found as a result of this confinement that even with careful precautions the vice of egg eating developed to a very considerable extent among the hens, and cutting the beaks was only a temporary check. Darkening the nesting place also had no effect, and at a loss to stop the practice by any specific means, we dug post-holes in the frozen ground with giant powder and erected temporary fences. This proved an effectual remedy, for as soon as the birds secured the run of the yards the practice ceased with the exception of one or two individual cases. This practice is evidently the immediate result of idleness resulting from close confinement and is best remedied by removing the cause of the evil.

The spring months were devoted almost exclusively to raising pure-bred chicks, and with the stock raised this year we have been able to replace all the old mongrel stock and culls, and now have for the first time all our pens filled with first-class breeding stock which adds much to the value and attractiveness of the department.

Numerous enquiries are received from time to time with reference to construction of buildings, feed of fowl, diseases, incubators, etc., all of which are answered as required.

HORTICULTURAL DEPARTMENT.

CHARLES WILSON, Gardiner.

Temporarily in Charge.

ORNAMENTAL SHRUB CULTURE.

In all fifty deciduous shrubs have been tested for four consecutive years. This year's work has confirmed the results of the three preceding years. Twelve varieties have been found to be hardy, nineteen semi-hardy and nineteen worthless.

HARDY.

Berberis Canadensis, American Barberry.*

Berberis Vulgaris, European Barberry.*

Berberis Vulgaris purpurea, Purple-leaved Barberry.*

Cornus Sanguinea, Crimson Dogwood.*

Legustrum, White-berried Privet.*

Ribes aureum, Yellow-flowering Currant.

Symphoricarpus racemosus, White Snowberry.*

Syringa Caerulea Superba, Lilac.

Syringa Villosa.

Syringa Vulgaris, Louis Spath.

Syringa Vulgaris, Princess Alexandria.

Viburnum opulus Sterilis, Snowball.

*Those starred have had young wood slightly winter killed two or three seasons, but not sufficiently to interfere seriously with the progress of the shrub. The balance do not suffer in the least from the severity of winter weather and will probably give good results throughout the State where the altitude does not exceed 5,000 feet.

SEMI-HARDY.*Berberis Aquifolia*, Mahonia.**Elaeagnus longipes*, Silver Thorn.**Hydrangia paniculata grandiflora*.**Lonicera Tartarica grandiflora*, Pink-flowering Honeysuckle.**Lonicera Tartarica alba*, White-flowering Honeysuckle.**Prunus triloba*, Double-flowering Plum.*Pyrus Japonica*, Japan Quince, Scarlet.**Pyrus Japonica*, Japan Quince, Blush.**Rhus glabra laciniata*, Cut-leaved Sumac.**Sambucus nigra aurea*, Golden-leaved Elder.**Spiraea Van Houttei*.*Syringa*, Garland.**Syringa*, Golden.*Syringa*, Large-flowering.*Tamarix*.*Viburnum*.*Syringa rothomagensis*.*Saulbucus nigra laciniata*, Cut-leaved Elder.*

* Young wood half kills back each winter. While this occurs under our local conditions there are more suitable localities in the State where these will answer well. Those not starred in this group do well here.

SHADE TREES.

The Russian and Carolina poplars have given the best results being particularly hardy. The former is a fast grower, branching and symmetrical with large leaves. The yellow cottonwood follows these two closely.

Box elders, raised from seed, are hardy and growthy, but this does not seem to be the case with imported stocks.

Mountain ash has proved to be hardy and a rapid grower of good shape.

The ash, elm, English elder, maple and burr oak have proved to be worthless unless under very favorable conditions.

ROSES AND FLOWERS.

Of the 28 kinds tried only two are hardy so that they can be grown without covering. These are the Persian yellow and Magna Charta. The former produces a great profusion of large yellow roses.

In the green houses 30 varieties of chrysanthemums and 20 of carnations have been propagated. These lend much attractiveness to the place and are a source of income as there is a great demand for them.

EXPERIMENTS IN FRUIT CULTURE.

APPLES.

The varieties given below have been set in the orchard most of them six years, and the balance four and five. The relative hardiness of these has now become a certainty and much more has been learned this year regarding their bearing capabilities and the quality of the fruit.

HARDY.

Anisette	Langfield
Bogdanoff	Number Twelve
Ben Davis	Orel
Duchess of Oldenburg	Okabena
Gano	Royal Table
Gipsey Girl	Thompson's No. 10
Good Peasant	Voronesh
Gideon	Wealthy
Hibernal	Yellow Transparent
Lead 3 N	Zuzoff

These kinds have all come into bearing with good results except for Orel, the fruit of which fell before maturity.

NOTES ON FRUIT.

Langfield.—Good yielder, medium size, medium early fall apple.

Wealthy.—Late fall or winter, big yielder, attractive fruit.

Gideon.—Late, large and attractive.

Hirbernal.—Good yielder of large greenish red fruit; winter.

CRABS.

Bailey's Crimson
 Florence
 Greenwood
 Hyslop
 Martha
 Orange

Pride of Minneapolis
 Russet
 Transcendant
 Whitney No. 20
 White Arctic

All these are now in bearing and may be classed as hardy except for Whitney and Orange.

Of these *Transcendant* was one of the most satisfactory, being early and yielding a large quantity of medium sized fruit.

Whitney.—Also produced well but is a little tender.

Russet.—Ripened early, fruit sweet and pear shaped.

Hyslop.—Has been a continuous bearer for three years, large quantity of medium sized fruit, but a little late.

Bailey's Crimson.—Good yielder, early and medium size.

Martha.—Good size, medium early.

Pride of Minneapolis.—Small, green, sweetish, medium early.

Orange.—Late and semi-hardy.

PLUMS.

Of the many varieties tried, but one, the Moldorka, has succeeded in ripening fruit. Two trees of the same age came into bearing, producing 30 pounds of large blueish fruit which ripened by September 10th.

STRAWBERRIES.

Of the large number tried in the original tests only five are recommended, viz.: Splendid, Bisel, Ivanhoe, Crescent and Bederwood. Of the 37 varieties of more recent introduction only two have been selected, the Wolverton and William Belt.

RASPBERRIES.

The Marlborough, Hausel and Brandywine, only, have given good results under the local conditions. The former freezes back slightly, but yields well. The two latter are the hardiest and are good yielders of good quality.

Though the Clark and Gurner freeze back they produce moderately well, but the berries are soft and of little account.

Columbian, Early King and Cuthbert have been tried, but freeze down every winter.

IRRIGATION DEPARTMENT.

S. FORTIER, Irrigation Engineer.

ONE SOURCE OF WASTE IN IRRIGATION.

In Montana, water for irrigation is conveyed for the most part through channels in earth. Ordinary earth is porous and will not retain water without considerable loss. When large volumes are carried in open canals over long distances the loss or waste of water from this one cause frequently exceeds one-fourth of the total flow. The percentage of loss varies in accordance with the physical conditions. In retentive clay soils the seepage loss is usually small. On the other hand when canals are located around foothills and over sandy and gravelly benches the loss is usually great.

In the absence of accurate measurements the loss in conveyance was not known. Irrigators were aware that much less water was available at their respective headgates than entered the main canal, but they attributed the deficiency largely to evaporation and absorption along the route. The water that seeped from the bottom of the canal could not be seen by the ditch rider and its effects were not always apparent on the land bordering the canal. The joint efforts of this Station and the Department of Agriculture in making a series of measurements on each of several typical canals in the State and publishing the results have directed general attention to the subject of the seepage loss from canals.

For two seasons the loss due to seepage on several of the large canals of the State has been ascertained. The following table gives in brief the principal results:

Date.	Total Flow at Head. Sec.-Ft.	Distance in Miles.	Loss in Sec.-Ft.	Percentage of total Supply Lost.
Middle Creek Canal, Gallatin County.				
June 10, 1899.....	98.9	4	21.5	21.7
" 27, 1900.....	63	4	12.2	19.4
Farmers' Canal, Gallatin County.				
July 30, 1900.....	133.1	10 $\frac{3}{4}$	23.59	17.71
West Gallatin Irrigation Canal, Gallatin County.				
July 18, 1900.....	114.45	38 $\frac{3}{4}$	38.93	34
The Big Ditch, Yellowstone County.				
August 9-13, 1900.....	254.47	22	65.05	25.55
The Republican Canal, Ravalli County.				
July 21-24, 1900.....	120.49	12 1-5	38.84	31.32

AN EQUITABLE DIVISION UNDER CO-OPERATIVE CANALS.

While enormous yields can be produced under irrigation the system is not without its drawbacks. One of these is the difficulty encountered in dividing water equitably among a large number of shareholders. In average years water is fairly abundant in this State, but owing to a light snowfall for two winters in succession the water supply has been deficient in many sections. The difficulty has been aggravated in not having proper headgates and measuring boxes. The division of water is usually based on the wild guesses of the water master.

So long also as the loss in conveyance was not even approximately known it was impossible to give each user his proper share. The irrigation department of the Experiment Station has begun a good work in determining for the canal owners the percentage of loss in their canals and devising suitable methods by which the flow through each farmer's headgate may be controlled and measured. Measuring devices, including both weirs and rating flumes, have been built under the supervision of the Station officers in different cultivated valleys of the State for the purpose of introducing more modern methods.

THE USE OF WATER IN IRRIGATION.

For the past two seasons experiments have been carried on by this Station in co-operation with the Office of Experiment Stations at Washington, D. C., to ascertain the actual quantities of water used in irrigation. Without this knowledge it would be impossible to reach any definite conclusions as to the agricultural possibilities of any irrigable tract of land. One might know the amount of the available water supply and the extent of the land to be irrigated, but if he did not know the average amount of water that should be applied per acre, the number of acres that might be reclaimed by the flow of a stream could not be determined.

In like manner, when a storage reservoir is to be built it is important to know, before the enterprise is begun, how much land a given quantity of water will irrigate. It is comparatively easy to obtain the capacity of the reservoir before any construction work is done, but if no tests have been made in the vicinity on the amount of water required per acre the area which the stored water will irrigate can only be roughly estimated.

Then, too, one of the first steps necessary in defining a water right is to ascertain the amount of water economically used. One of the greatest difficulties experienced by the courts in settling water rights is the lack of knowledge on this particular subject. The following table contains a brief summary of the more important investigations on the use of water in irrigation:

Duty of Water in 1899.

Kind of Crop.	Name of County.	Area Irrigated Acres.	Depth of Water.			Water* Applied per Acre. Tons.	No of Irrigations.	Yield per Acre.
			Irrigation.	Rain.	Total.			
Red Clover.	Gallatin	27.44	1.02	.44	1.46	1386.8	2	3.0 tons.
Peas	do	4.23	1.10	.41	1.51	1495.6	2	31.25 bu.
Barley	do	5.25	1.98	.42	2.40	2692.05	2	45.00 bu.
Wheat.....	do	6.02	1.98	.42	2.40	2692.05	2	57.89 bu.
Barley	do	66.39	.98	.41	1.39	1332.4	1	.....
Oats.....	do	23.41	1.53	.38	1.91	2080.2	1	51.00 bu.
do	do	7.26	1.34	.36	1.70	1821.9	2	72.75 bu.
do	do	2.48	2.16	.36	2.52	2936.8	2	72.75 bu.
do	do	25.09	1.28	.44	1.72	1740.3	1	.....

* Not including Rainfall.

Duty of Water in 1900.

Kind of Crop.	Name of County.	Area Irrigated Acres.	Depth of Water.			Water Applied per Acre. Tons.†	No. of Irrigations.	Yield per Acre.
			Irrigation Ft.	Rain Ft.	Total Ft.			
Red Clover.	Gallatin	66.39	1.98	.44	2.42	3290.3	2	.....
Barley	do	4.14	1.50	.28	1.78	2420.2	2	46.5 bu.
Oats.....	do	25.09	.64	.39	1.03	1400.4	2*	.....
Wheat	do	1.00	.77	.30	1.07	1454.8	2	38.33 bu.
Red Clover.	do	1.00	.77	.30	1.07	1454.8	2	1.58 tons.
Oats.....	do	1.00	.56	.39	.95	1291.6	2	75.58 bu.
Peas.....	do	1.00	.56	.39	.95	1291.6	2	1,330 lbs.
Barley	do	1.00	1.17	.28	1.45	1971.5	2	87.29 bu.
Oats.....	do	8.51	1.39	.40	1.79	2433.9	2	74.67 bu.
Barley	do	4.42	1.96	.42	2.38	3236.0	2	68.59 bu.
Red Clover.	do	7.26	2.70	.44	3.14	4269.2	4	5.02 tons.
Red Clover.	do	35.90	1.79	.44	2.22	3018.3	3	.....
Alfalfa.....	Yellowstone	53.40	1.30	.44	1.74	2365.8	1	5.17 tons.
Orchard ...	Ravalli	40.00	1.46	.13	1.59	2161.9	4	.....
Oats.....	do	161.70	1.30	.13	1.43	1944.3	2	33.37 bu.
Oats.....	do	102.2	6.06	.13	6.19	8416.0	2	34.03 bu.

* About two-fifths irrigated on second irrigation. † Irrigation water.

THE AMOUNT OF WATER REQUIRED.

In the spring of 1900, a tract of land on the western edge of the Station farm was set apart for experiments on the proper amount of water to apply in irrigation. Sixteen rectangular plats 50x100 feet were laid off, with an intervening space between every two plats. A flume (Fig. 1) extended along the west edge of the row of plats and conveyed water from the nearest ditch to each plat. The amount of water applied to any one plat was measured by a weir box at the head of the flume.

All plats were seeded to oats May 21, 1900, at the rate of two bushels of seed per acre. On May 30 the percentage, by weight, of soil moisture in the upper two feet of soil over the entire number of plats ranged from 17.29 to 20.95 and averaged 18.95 per cent. The following table gives the results obtained on plats No. 1 to 8, inclusive. Plat No. 1 was not irrigated, but it received some moisture from an adjacent ditch.

No. of Plat.	Depth of Irrigation in Inches.	Yield per Acre.		Yield per Acre of Grain and Straw Tons.	Water Used per Acre. Tons.	No. Tons Water Applied for Each Ton Produce.
		Grain Bushels.	Straw Pounds.			
1.....	0	46.1	1655	1.61		
2.....	2	61.7	2345	2.29	227	99
3.....	8	68.2	2823	2.57	906	353
4.....	9	73.5	2988	2.74	1020	372
5.....	12	74.8	3075	2.81	1360	484
6.....	16	78.2	3398	3.03	1813	599
7.....	20	77.6	3284	2.96	2266	765
8.....	24	83.5	3215	3.03	2719	898

DISCHARGE OF THE PRINCIPAL RIVERS OF MONTANA.

For several years the irrigation department of the Station has supervised and conducted the hydrographic work of the U. S. Geological Survey in Montana. Gaging stations are established and maintained at favorable locations on the principal rivers of the State and measurements made of the flow at each station from four to twelve times during each year. An observer residing near the gaging station observes and records the height of water at least once a day. These records are mailed to the Experiment Station and are forwarded from thence to Washington, D. C. The data obtained from a number of stream measurements, together with the daily records of the observer, enable the engineer to compute with reasonable accuracy the daily flow, or discharge, throughout the year. The records for the year 1900 have been thus computed and are herein given for the following rivers: Yellowstone, Gallatin, West Gallatin, Middle creek, Madison, Jefferson, Missoula, Big Blackfoot, Bitter Root and Milk river. It should be observed that when ice forms on the surface of a stream neither the gage heights nor the flow can be accurately determined. In the accompanying tables the discharges are given in cubic feet per second. Since 40 Montana miners' inches are equivalent to one cubic foot per second the flow may be converted into miners' inches by multiplying the figures given by the number 40.

Daily Discharge of West Gallatin River, in Second-feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	700	560	500	630	1200	4165	1300	560	440	560	500	330
2	700	560	500	700	1300	3610	1300	560	440	560	500	330
3	700	560	500	700	1460	4570	1105	560	440	500	500	358
4	700	560	500	700	1745	4900	935	580	560	560	500	385
5	700	630	500	775	1995	4985	935	580	560	560	500	440
6	700	630	500	850	2610	5410	935	500	560	560	500	440
7	700	630	500	1020	2327	4827	935	500	560	560	500	440
8	630	630	500	850	2465	4325	935	500	530	500	500	385
9	630	630	500	775	2610	4405	935	500	440	500	500	385
10	630	630	500	775	3223	4165	850	500	440	500	500	385
11	630	630	500	775	4005	4652	850	500	440	500	440	385
12	630	440	500	775	4005	3145	850	500	385	500	385	385
13	630	440	500	775	3223	3223	775	500	440	500	440	385
14	630	440	500	775	2835	3223	775	500	440	500	440	385
15	560	440	500	775	2760	3533	775	500	500	500	440	385
16	560	440	500	850	2610	3145	700	500	440	500	440	358
17	560	440	500	775	2610	2835	700	518	440	500	440	330
18	560	440	500	850	2685	2610	700	.....	500	500	385	330
19	560	440	500	935	2395	2685	700	500	500	500	330	330
20	560	440	500	1062	2535	2760	700	500	500	500	280	330
21	560	560	500	1200	2610	2835	630	500	500	385	280	330
22	560	560	500	1352	2990	2685	700	500	440	440	330	330
23	560	560	500	1572	3067	2685	630	500	560	500	330	330
24	560	560	500	1250	3377	2685	630	518	500	500	330	358
25	560	560	500	1105	3533	1995	630	518	500	500	330	358
26	560	560	500	1200	4325	1995	630	560	500	500	330	330
27	560	560	500	1200	5155	1630	665	530	500	440	330	330
28	560	500	500	1300	5410	1405	630	530	560	385	330	330
29	560	.....	630	1300	4652	1405	560	530	500	385	330	330
30	560	.....	630	1200	4652	1300	616	500	518	440	330	330
31	560	.....	630	.....	4005	.....	630	440	.....	440	.....	320

Daily Discharge of Madison River, Near Red Bluff, in Second Feet, for 1900.
(Including Cherry Creek)

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	860	3005	4840	2075	1640	1640	1850	1850	1640
2	(a)	.....	860	3645	4305	2075	1640	1640	1850	1850	1640
3	860	4040	5110	1963	1640	1640	1850	1850	1640
4	(a)	.....	.....	1430	4040	5110	1850	1640	1640	1850	1640	1640
5	1430	4173	5326	1850	1640	1640	1850	1640	1640
6	1430	3775	5380	1850	1640	1640	1850	1640	1640
7	1640	3908	5380	1850	1640	1640	1850	1640	1640
8	(a)	860	1430	4040	5110	1850	1640	1640	1850	1640	1640
9	1430	4173	5110	1850	1745	1640	1850	1640	1640
10	1430	4305	5110	1850	1850	1640	1850	1640	1640
11	(a)	.....	.....	1430	4624	4840	1850	1850	1850	1850	1640	1640
12	1430	4840	4705	1850	1850	1850	1850	1640	1640
13	1430	5110	4040	1850	1745	1640	1850	1640	1640
14	1430	4840	3775	1850	1640	1640	1850	1640	1640
15	(a)	860	1535	4438	3515	1850	1640	1640	1850	1640	1640
16	1640	4173	3260	1850	1640	1640	1850	1640	1640
17	1745	3775	4305	1850	1640	1640	1850	1640	1640
18	(a)	.....	.....	1850	3645	2648	1850	1640	1640	1850	1640	1640
19	1850	3260	2530	1850	1640	1640	1850	1640	1640
20	1850	3515	2300	1850	1640	1640	1850	1640	1640
21	1850	3593	2300	1850	1640	1640	1850	1640	1640
22	(a)	860	2075	3515	2300	1850	1640	1640	1850	1640	1640
23	2300	3645	2188	1850	1640	1640	1850	1640	1640
24	2530	3960	2075	1850	1640	1640	1850	1640	1640
25	(a)	.....	.....	2530	4173	2075	1850	1640	1640	1850	1640	1640
26	2530	4570	2075	1850	1640	1850	1850	1640	1640
27	2530	5110	2075	1850	1640	1850	1850	1640	1640
28	2530	5380	2075	1850	1640	1850	1850	1640	1640
29	860	2530	5655	2075	1850	1640	1850	1850	1640	1640
30	2577	5655	2075	1640	1640	1850	1850	1640	.....
31	5518	.....	1640	1640	.....	1850	.....	.....

(a) Ice.

Daily Discharge of Jefferson River, at Sappington, in Second Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	2020	3870	5890	1870	600	515	1090	1590	1590
2	(a)	2170	3870	5705	1725	600	515	1205	1590	1590
3	(a)	2565	4050	5520	1590	600	515	1265	1590	1590
4	(a)	2810	4140	5705	1590	515	515	1364	1590	1590
5	(a)	2980	4410	5890	1455	515	600	1455	1590	1725
6	(a)	3150	4688	4050	1455	515	600	1495	1455	1725
7	(a)	3330	5058	5705	1455	515	600	1455	1455	1725
8	(a)	3330	5248	5705	1455	515	600	1455	1455	1725
9	(a)	3330	5613	5335	1325	515	600	1455	1455	1725
10	2325	3065	5985	5150	1325	515	685	1455	1455	1725
11	2020	2810	6365	4965	1205	515	685	1455	1455	1725
12	2020	2645	6850	4410	1205	515	685	1455	1455	1590
13	2020	2645	8050	4050	1205	515	685	1325	1455	1590
14	1870	2645	8665	4050	1090	515	685	1325	1455	1590
15	1870	2645	8973	3870	980	515	685	1325	1455	1590
16	1870	2810	9075	3690	875	515	685	1325	1455	1590
17	1725	2810	8773	3870	775	515	685	1325	1455	1455
18	1870	2810	8358	4050	775	515	775	1325	1455	1455
19	2020	2810	8050	4230	685	515	825	1205	1455	1455
20	2020	2980	7740	4410	685	515	875	1205	1455	1455
21	2170	2980	7445	3870	685	515	875	1205	1455	1455
22	2170	3150	7350	3420	685	515	875	1205	1455	1455
23	2325	3330	6948	2810	685	515	875	1325	1455	1455
24	2485	3420	6850	2645	685	515	875	1325	1455	1455
25	2485	3600	6655	2485	685	515	875	1325	1455	1455
26	2485	3690	6558	2325	600	515	980	1455	1455	1455
27	2405	3870	6460	2170	600	475	980	1455	1455	1455
28	2248	3870	6460	2095	600	475	980	1455	1455	1325
29	2020	3870	6655	2020	600	475	980	1455	1590	1325
30	1870	3870	6460	2020	600	515	980	1455	1590	1325
31	1870	.....	6175	.....	600	515	.....	1590	.....	1325

(a) Ice.

Daily Discharge of Gallatin River, at Logan, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	940	1575	3870	605	290	400	530	605	680
2	940	1575	3870	530	290	400	530	605	680
3	765	.....	.....	940	1638	4240	530	290	460	530	605	680
4	940	1950	4240	460	290	460	605	605	680
5	940	1950	4333	460	290	460	643	605	680
6	940	2210	4615	460	290	460	680	605	680
7	1030	1345	940	2665	4520	460	290	460	680	605	680
8	940	2505	4055	460	345	460	680	605	680
9	940	2665	3685	400	345	460	605	605	686
10	850	.....	.....	940	3078	3415	345	345	460	605	605	605
11	940	3595	2585	345	345	460	605	605	605
12	940	4055	2210	290	345	460	605	605	605
13	940	4240	2210	240	345	460	605	605	605
14	(a)	940	940	3415	2013	240	345	460	605	605	605
15	1030	3243	1763	240	345	460	605	605	605
16	1030	2995	1575	240	345	460	605	605	605
17	850	.....	.....	1030	2995	1575	240	345	460	605	605	605
18	1130	2995	1460	240	345	460	605	723	605
19	1130	2995	1235	240	345	530	605	895	605
20	1130	2995	1235	240	345	530	605	1030	605
21	(a)	1030	1130	2995	1080	240	345	530	605	1080	605
22	1130	2995	1030	240	345	530	605	1030	605
23	1345	2995	1030	240	345	530	605	940	605
24	1030	.....	.....	1460	3078	1030	240	345	530	605	850	605
25	1575	3505	940	240	345	530	605	765	605
26	1638	3685	940	240	400	530	605	680	605
27	1575	4333	850	290	400	530	605	680	605
28	1030	850	1575	4805	765	290	400	530	605	680	605
29	1575	4805	680	290	400	530	605	680	605
30	1575	4055	605	290	400	530	605	680	(a)
31	1030	.....	.....	.....	4240	.....	290	400	.....	605	.....	(a)

(a) Ice.

**Daily Discharge of Yellowstone River, above Livingston, in Second-Feet,
for 1900.**

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	.....	1265	2490	10660	7270	3395	2100	1715	1500	1305
2	(a)	.....	1340	2855	11540	6945	3270	2100	1733	1500	1355
3	(a)	.....	1420	3060	12485	6600	3240	2050	1760	1500	1340
4	(a)	.....	1500	4075	12975	6470	3130	2050	1733	1500	1340
5	(a)	.....	1500	4730	13725	6220	3060	2050	1715	1500	1340
6	1380	(a)	(a)	1500	5980	15080	5980	3060	2050	1715	1500	1340
7	(a)	(a)	1670	5740	15363	5812	2990	2000	1715	1475	1340
8	(a)	(a)	1950	5623	13375	5575	2990	2000	1688	1460	1340
9	(a)	(a)	1850	6920	14530	5505	2923	1950	1670	1460	1340
10	(a)	(a)	1585	8970	11315	5345	2855	1950	1645	1420	1340
11	(a)	(a)	1585	10375	10875	5165	2790	1900	1628	1355	1340
12	(a)	(a)	1585	11540	10455	5005	2725	1900	1585	1340	1340
13	1420	(a)	(a)	1585	9140	10250	4830	2725	1900	1585	1395	1190
14	(a)	1340	1628	7215	11773	4690	2665	1900	1585	1420	1265
15	(a)	.....	1628	5980	12730	4630	2665	1850	1545	1380	1265
16	(a)	.....	1585	5930	12485	4495	2605	1823	1585	1460	1265
17	(a)	.....	1585	6420	12150	4345	2548	1805	1585	1395	1265
18	(a)	.....	1585	6220	11090	4305	2490	1805	1585	1305	1265
19	(a)	.....	1670	5670	10660	4250	2490	1850	1585	(a)	1265
20	1340	(a)	.....	1950	5860	11090	4160	2433	1850	1545	(a)	1265
21	1340	1265	2150	6170	11090	4075	2433	1805	1585	(a)	1265
22	2375	6600	11315	4040	2433	1805	1545	(a)	1265
23	2923	7070	11005	3900	2375	1760	1585	(a)	.....
24	2605	7550	10373	3815	2375	1760	1585	1190	1120
25	2605	7933	10170	3730	2375	1760	1545	1205	1190
26	2490	9955	9860	3730	2375	1733	1545	1340	1155
27	1340	.....	2375	12485	9245	3730	2318	1715	1545	1380	1155
28	2490	14805	8570	3655	2318	1715	1545	1340	1030
29	2605	13375	8150	3575	2260	1715	1545	1265	1030
30	2663	11450	7935	3500	2205	1715	1500	1265	.....
31	1265	.....	10660	.....	3420	2150	.....	1500	.....	(a)

(a) Ice.

Daily Discharge of Milk River, at Havre, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	355	355	76	21	30	76	129	(a)
2	438	315	76	12	12	76	129	(a)
3	396	280	63	12	12	91	129	(a)
4	315	216	63	12	12	109	109	(a)
5	280	216	63	12	39	149	109	(a)
6	248	216	63	12	39	355	109	(a)
7	216	216	50	12	50	355	109	(a)
8	189	189	50	8	76	280	109	(a)
9	189	189	63	8	91	248	109	(a)
10	485	169	149	76	8	169	216	76	(a)
11	485	149	149	91	12	149	189	63	(a)
12	840	129	149	50	232	149	189	109	(a)
13	587	149	129	50	203	149	169	149	(a)
14	587	149	129	39	149	76	169	109	(a)
15	485	189	129	39	109	76	248	169	(a)
16	438	820	129	39	76	63	280	(a)	(a)
17	315	1575	129	39	63	63	315	(a)	12
18	396	1205	149	39	39	63	280	(a)	12
19	280	880	109	30	30	63	248	(a)	12
20	280	640	109	30	30	63	216	(a)	12
21	280	587	109	30	21	76	216	(a)	12
22	280	760	109	30	21	109	149	(a)	30
23	280	587	109	21	12	109	149	(a)	(a)
24	355	485	91	21	12	91	129	(a)	(a)
25	438	438	91	21	12	76	129	(a)	(a)
26	438	396	109	21	12	76	129	(a)	(a)
27	280	355	91	21	12	76	129	(a)	(a)
28	355	280	91	30	12	63	129	(a)	(a)
29	280	315	91	21	12	63	129	(a)	(a)
30	315	280	76	21	12	76	109	(a)	(a)
31	315	.....	21	30	.....	109	.....	(a)

(a) Ice.

Daily Discharge of Middle Creek, above Flander's Mill, in Second-Feet,
for 1900.

Day	June	July	Aug.	Sept.	Oct.	Day	June	July	Aug.	Sept.	Oct.
1....	118	66	48	48	16....	.....	88	51	48	.....
2....	118	66	48	48	17....	.....	88	51	48	.....
3....	88	66	48	48	18....	232	88	51	48	.....
4....	88	66	48	48	19....	192	88	51	50	.....
5....	118	88	48	48	20....	232	88	51	50	.....
6....	88	66	48	48	21....	321	66	51	50	.....
7....	88	66	48	48	22....	232	66	50	48	.....
8....	118	66	48	48	23....	368	66	50	48	.....
9....	118	66	48	48	24....	232	66	50	48	.....
10....	118	57	48	48	25....	232	88	50	48	.....
11....	118	57	48	48	26....	192	66	50	48	.....
12....	88	55	48	48	27....	192	66	50	48	.....
13....	88	53	48	48	28....	192	88	50	48	.....
14....	88	53	48	.....	29....	163	66	50	48	.....
15....	118	51	48	.....	30....	118	66	48	48	.....
						31....	.....	66	48	.....	.....

Daily Discharge of Bitter Root River, Near Missoula, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1255	1255	.....	1930	.....	7210	3570	950	1080	1165	1880	1123
2	1165	1255	.....	2040	.....	7355	3260	950	1080	1080	1930	1123
3	1123	1255	.....	2540	6400	8100	3110	930	1010	1080	1930	1123
4	1123	1165	910	3035	7070	9000	2680	910	950	1165	1730	1123
5	1165	1045	930	3570	8700	9600	2540	890	950	1165	1635	1165
6	1165	1010	930	3810	9600	10200	2475	870	1010	1123	1635	1165
7	1165	980	980	3975	10800	10650	2475	870	1045	1165	1445	1255
8	1165	950	1045	3730	10500	9300	2475	870	1045	1210	1350	1350
9	1123	950	1080	3490	9750	8700	2280	870	1010	1210	1540	1255
10	1080	980	1080	3410	10950	7800	2220	870	1010	1165	1350	1255
11	1080	(a)	1255	3335	12650	6400	2220	870	1010	1165	1255	1165
12	1123	(a)	1303	3260	14638	6150	1930	853	980	1165	1210	1123
13	1165	(a)	1350	3335	18150	6150	1830	853	980	1080	1210	1080
14	1350	(a)	1445	3260	15200	5910	1830	853	950	1045	1165	1080
15	1540	(a)	1493	3260	11700	5910	1730	853	950	1045	1165	1080
16	1540	(a)	1683	3410	10200	8700	1635	853	950	1010	1165	1080
17	1445	(a)	1830	3730	10350	8250	1540	853	1350	1010	1165	1165
18	1398	(a)	1930	4145	10500	7800	1445	853	1350	1045	1165	1165
19	1350	(a)	1985	4230	10650	7500	1398	835	1350	1045	(a)	1255
20	1350	(a)	2040	4320	9600	6795	1398	835	1255	1080	(a)	1255
21	1255	(a)	2040	4410	8400	7210	1255	800	1255	1165	(a)	1255
22	1210	(a)	2100	4600	8700	7500	1210	800	1255	1255	(a)	1255
23	1210	(a)	2100	4410	8400	7650	1163	800	1210	1350	(a)	1255
24	1210	(a)	2160	4230	8250	7500	1165	835	1255	1445	(a)	1165
25	1123	(a)	2160	4060	8100	7800	1123	835	1255	1165	1255	1165
26	1123	(a)	2280	4060	8100	6660	1123	835	1350	1540	1165	1165
27	1123	(a)	2160	3975	8250	5670	1123	853	1350	1730	1165	1080
28	1165	(a)	2040	3975	8250	4800	1123	870	1350	1780	1165	1010
29	1165	.....	2100	.....	8250	4230	1123	870	1255	1780	1165	950
30	1165	.....	1930	.....	7355	4060	1010	950	1255	1830	1123	950
31	1255	.....	1930	.....	6795	.....	980	1010	.....	1880	.....	950

(a) Ice.

**Daily Discharge of Big Blackfoot River, Near Bonner, in Second-Feet,
for 1900.**

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	824	743	662	1310	3514	3908	1830	1026	986	824	743	(a)
2	824	662	662	1391	3988	4064	1781	1026	905	824	743	(a)
3	905	662	702	1435	3988	4064	1733	986	905	824	783	(a)
4	864	662	581	1733	4160	4064	1643	986	905	824	743	(a)
5	783	702	380	1980	5106	3749	1643	986	905	824	783	(a)
6	702	621	420	2325	5877	3988	1553	986	905	824	824	1067
7	824	662	500	2520	6005	3749	1533	986	905	743	783	986
8	783	581	702	2650	5877	3514	1512	986	905	743	783	824
9	783	540	905	2715	5363	3514	1472	945	824	824	783	743
10	783	621	1512	2585	6005	3357	1472	1026	824	824	824	702
11	783	702	2085	2585	6648	3125	1391	986	905	743	783	783
12	702	702	2980	2520	8061	2980	1391	905	905	743	743	702
13	945	581	3125	2455	12559	2910	1391	905	905	743	783	702
14	905	581	2085	2325	11274	2980	1391	905	905	743	702	702
15	864	540	1781	2455	9989	2980	1310	905	824	743	743	662
16	864	460	1598	2520	8704	3125	1350	1067	824	824	743	662
17	783	621	1643	2520	9089	3592	1350	905	824	945	783	581
18	864	540	1350	2520	8961	3514	1269	1067	905	783	662	621
19	864	702	1391	2780	8575	3125	1229	905	824	702	702	621
20	743	662	1148	2980	7676	2910	1269	864	824	702	(a)	662
21	783	662	1107	3200	7290	2980	1229	905	905	662	(a)	864
22	824	702	1107	3278	7162	2845	1188	905	824	743	(a)	905
23	743	702	1188	3592	6391	2715	1107	905	824	702	(a)	783
24	662	662	1269	3749	6391	2650	1026	905	824	783	(a)	824
25	702	662	1229	3671	5877	2520	1026	805	824	702	(a)	783
26	743	581	1188	3671	5234	2325	1148	905	743	743	(a)	824
27	662	621	1269	3671	5106	2200	1229	905	743	824	(a)	783
28	702	621	1310	3435	4977	2085	1067	905	824	783	(a)	702
29	702	.....	1188	3357	4977	2030	1067	864	824	743	(a)	702
30	743	.....	1229	3278	4720	1880	1107	945	824	783	(a)	702
31	743	.....	1310	.....	3988	.....	1107	864	.....	743	.....	581

(a) Ice

Daily Discharge of Missoula River, at Missoula, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	(a)	1534	2480	6540	9400	3260	1404	1278	1430	1560	(a)
2	(a)	(a)	1560	2645	6880	9050	3160	1340	1245	1495	1560	(a)
3	(a)	(a)	1495	3160	7475	9050	2980	1404	1300	1470	1560	(a)
4	(a)	(a)	1365	3560	8175	8875	2760	1340	1278	1664	1625	(a)
5	(a)	(a)	980	4100	9155	.....	2678	1245	1404	1600	1664	1860
6	(a)	(a)	1030	4400	10000	.....	2678	1245	1404	1560	1625	1885
7	(a)	(a)	1365	4900	10600	8175	2645	1190	1495	1664	1625	1820
8	(a)	(a)	1560	4650	10120	8175	2513	1190	1430	1625	1625	1820
9	(a)	(a)	2595	4725	9800	7755	2430	1245	1404	1560	1600	1690
10	(a)	(a)	3600	4475	11120	7580	2315	1135	1365	1560	1625	1600
11	(a)	(a)	5190	4400	12950	6775	2232	1300	1365	1534	1534	1470
12	(a)	(a)	6950	4400	23600	6240	2150	1245	1300	1495	1430	1365
13	1690	(a)	6300	4225	23600	5940	2070	1245	1278	1495	1430	1300
14	1460	(a)	4025	4350	20550	5550	2025	1223	1245	1470	1470	1300
15	1730	(a)	3400	4275	17980	5700	1950	1190	1278	1495	1430	1365
16	1664	(a)	2545	4475	16200	5940	1885	1190	2348	1495	1430	1340
17	1534	450	2760	4475	16850	6775	1860	1080	1600	1470	1600	1365
18	1560	930	2645	4400	16700	7580	1820	1113	1625	1430	(a)	1340
19	1560	(a)	2215	4725	15850	6390	1755	1113	1690	1470	(a)	1300
20	1560	(a)	2348	5100	15450	6000	1625	1080	1664	1470	(a)	1340
21	1600	(a)	2392	5350	13950	5575	1534	1030	1625	1430	(a)	1664
22	1534	1495	2480	5850	13100	5490	1470	1245	1560	1560	(a)	1885
23	1534	1534	2678	6150	12850	5150	1534	1278	1560	1560	(a)	1560
24	1495	1664	2513	6300	12120	5025	1495	1340	1625	1560	(a)	1430
25	1223	1664	2480	6300	11520	4900	1534	1404	1560	1534	.....	1340
26	830	1625	2562	6450	10880	4900	1534	1430	1560	1495	(a)	1300
27	980	1625	2562	6450	10920	4400	1495	1430	1560	1470	(a)	1340
28	730	1625	2562	6300	11000	4025	1495	1340	1534	1495	(a)	1190
29	(a)	.....	2430	6300	10600	3700	1534	1300	1534	1600	(a)	1013
30	(a)	2265	6300	10000	3460	1430	1365	1430	1534	(a)	980
31	(a)	2348	9600	1430	1340	1560	(a)

(a) Ice

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LETTER OF TRANSMITTAL.

BOZEMAN, MONTANA, December 31, 1902.

To His Excellency, JOSEPH K. TOOLE,

Governor of Montana.

DEAR SIR:—In accordance with the Congressional Act of March 2, 1887, I have the honor to transmit herewith the ninth annual report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1902, the results of investigations of the several departments are reported to the end of the State year, November 30, 1902.

Very respectfully,

S. FORTIER,

Director.

MONTANA AGRICULTURAL EXPERIMENT STATION.

STATE BOARD OF EDUCATION.

JOSEPH K. TOOLE, Governor,	} Ex-Officio.....	Helena
JAMES DONOVAN, Attorney-General,		
W. W. WELCH, Supt. of Public Instruction,		
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STATION STAFF.

S. FORTIER, Ma. E.....	Director and Irrigation Engineer
F. W. TRAPHAGEN, Ph. D., F. C. S.....	Chemist
J. W. BLANKINSHIP, Ph. D.....	Botanist
R. A. COOLEY, B. Sc.....	Entomologist
F. B. LINFIELD, B. S. A.....	Agriculturist
R. W. FISHER, B. S.....	Assistant Horticulturist
EDMUND BURKE.....	Assistant Chemist
H. C. GARDINER.....	Student in Charge of Poultry

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be
addressed to the Director,
MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to
any citizen of Montana who sends his name and address to the
Station for that purpose.

REPORT OF THE TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1901-1902.

DR.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1902, as per Act of Congress approved March 2, 1887.....\$15,000.00

CR.

By Salaries.....	\$ 9,018.25
Labor.....	2,215.06
Publications.....	1,232.88
Postage and stationery	182.68
Freight and express	438.17
Heat, light, water and power.....	281.72
Chemical supplies.....	135.56
Seeds, plants and sundry supplies.....	470.12
Fertilizers.....	32.50
Feeding stuffs.....	105.54
Library	223.81
Tools, implements and machinery.....	185.05
Furniture and fixtures	269.30
Scientific apparatus.....	186.36
Contingent expenses.....	23.00

Total.....\$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1902; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00, and the corresponding disbursements \$15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed:

Attest:

PETER KOCH,
Custodian.

J. M. ROBINSON,
PETER KOCH,
Auditors.

REPORT OF THE DIRECTOR.

CHANGE IN STATION YEAR.

Since the establishment of the Station each annual report has included the results of investigations for the fiscal year ending June 30 of each year. This division of time does not conform to the crop growing season and few, if any, of the Station officers can make a report of the operations of the summer season until after harvest time. The effect has been unnecessary delay in the publishing of results. By resolution of the Station council it was decided to make the Station year conform to the state year which terminates November 30. In this report the financial statement is given for the fiscal year as usual, but the results of experiments and field operations generally are reported to November 30, 1902.

THE OUTLOOK FOR AGRICULTURE.

There never was a time in the history of this state when the outlook for agriculture was brighter. The fertile soil of valley and bench lands has yielded abundant harvests and the prices paid for the products of both field and range have been above the average. The capital stock as well as the annual dividends of the farmer has increased. Agricultural land, particularly improved farm land, has steadily risen in value. In consequence of these favorable conditions the Montana rancher is prosperous and contented.

It is likewise true that the people of the state generally are beginning to regard agriculture as the safe foundation upon which

much of our future prosperity will be built. They have already become accustomed to rely on the taxes paid by the stockman and farmer to provide means to uphold and maintain a state government. That these two industries pay a large proportion of the total expenditures is evident from the following figures which give the assessed valuations for the past eight years. In this brief summary is given only three items and the total assessment for each year. It is not to be understood that the assessed values of land here given represent the total assessment. These are exclusive of the improvements on the farms as well as the farming utensils, machinery, wagons, etc. Besides many of the towns and cities of the state are, to a large extent, dependent on these basic industries of farming and stock raising. So that agriculture in its broadest sense not only provides the greater part of the revenue of the state as the result of direct taxation, but it also assists in building up towns and cities and in producing raw material for the manufacturer and larger shipments for the transportation company :

Year.	Assessed Value of Farm Land.	Assessed Value of Live Stock.	Assessed Value of Mines.	Total Annual Assessment.
1895	\$17,020,977	\$19,439,165	\$ 5,128,870	\$124,076,585
1896	17,069,855	18,923,860	4,236,289	120,697,847
1897	17,821,995	19,927,414	8,631,251	130,757,411
1898	19,149,354	22,229,761	8,517,518	133,969,519
1899	20,499,746	23,705,794	8,943,267	142,117,655
1900	21,416,061	26,281,473	14,168,708	153,401,594
1901	23,185,370	28,266,112	16,281,271	166,787,588
1902	25,300,972	32,517,589	5,891,358	185,725,657

THE EXTENSION OF AGRICULTURE.

Agriculture in Montana may be developed in many ways and along various lines. In the past only a few industries have received careful attention while all the others have been neglected. If substantial progress is to be made there must of necessity be a more complete development. This is particularly true of all those

industries which are adapted to local conditions. Because native grasses grow so abundantly under arid conditions, is it wise to depend alone on the range? The quantity and quality of the natural product are sure indications of the large returns that might be obtained under cultivation and irrigation.

In the fuller development to which we refer there can be no question that irrigation is the chief factor. Farming without irrigation in an arid climate is a one-sided business. . On one side of the irrigation canal are to be seen comfortable homes, shade trees, gardens, orchards, domestic animals and well cultivated fields; on the other side straw stacks, bunch grass and range steers. The cultivation of dry farms and the production of range beef are important industries, but these alone cannot make a farm home attractive. It is the effect of water from the neighboring stream which adds such a charm to the irrigated homestead. The irrigation stream is the common foster parent which nourishes every farm industry. It produces flowers for the honey bees, food for the chickens, alfalfa for the dairy cows, the best of rations for fattening stock, and fruit and fresh vegetables for the table.

PROGRESS IN IRRIGATION.

Since agriculture in this state is dependent to a large extent on irrigation, every acre that is rendered productive by means of water will tend to promote agriculture. Progress in irrigation may be made in any one of the ways herein named.

(1) The proprietor of the irrigated homestead is now laboring under difficulties which should be removed. In about nine cases out of every ten, rights to the use of water are unknown and undefined. In so lax a system an equitable distribution is impossible for the actual necessities of each water user have never been determined. It is also evident that an economical use of water can seldom be practiced. The water which should be applied to ten quarter sections may be used and wasted on five, while the remaining five produce half a crop on account of a lack of water. When the rights of the proprietor of irrigated land are clearly de-

fined and recorded, the value of his holding will be enhanced and this will tend to induce others to extend their irrigated areas.

(2) Montana has not yet reached so advanced a stage in irrigation that individual effort is powerless to obtain a water supply. There are still hundreds of small streams that are not wholly utilized from which water may be cheaply conveyed to arable land. There are besides, the modern pump, the tunnel driven to bed rock in the bottom of a ravine, and the small storage reservoir. One, or more, of these means may be used by the individual to secure a water supply.

(3) One of the most successful ways of promoting irrigation is by means of the co-operative canal. The united effort of from 10 to 20 industrious farmers who make up their minds not to be influenced by minor differences of opinion but to work harmoniously together for the accomplishment of a common purpose, may complete in a satisfactory manner a large canal, or storage reservoir.

(4) In 1894 Congress, under the provision of the Carey Act, gave to each arid state the right to select 1,000,000 acres of land and to control its irrigation and settlement. Only 14,000 acres of this grant have been reclaimed. The large area yet remaining affords an inviting field for capital and co-operative effort.

(5) The construction of large enterprises by the government under the Federal Act passed last June.

THE DIVERSIFIED FARM.

In our agricultural development a few industries such as stock raising have forged ahead and left the others either far in the rear or out of the race altogether. This Station has tried to show for years past that there are other important industries such as dairying, poultry and hog production that might receive attention and become in time successful without in any way retarding the success of the present leading industries.

That such industries and many more of a secondary character not named are much needed is clearly shown by the following statistics of imports, collected by the Secretary of the Montana State Board of Horticulture.

SUMMARY OF AGRICULTURAL PRODUCTS SHIPPED INTO MONTANA DURING 1901, AS COMPILED BY MR. F. H. RAY, ASSISTANT STATE EXAMINER

Meats.....	\$2,217,047
Poultry and eggs.....	1,113,078
Dairy products.....	1,081,795
Vegetables	210,019
Grain	204,451
Miscellaneous	194,004
<hr/>	
Total.....	\$5,020,394

A larger number of smaller irrigated farms, more intensive farming and above all more diversified products will not only reduce the imports but increase the exports. The millions of dollars that are now annually sent out of the state for such products as butter, cheese, ham and eggs should go into the pockets of the farmers. We must look to the diversified farm to retain these millions. No radical changes are involved in making provision to supply these products. It does not call for a division of the large farm. If the owner of 320 acres believes he can make more money in raising alfalfa and feeding it to stock no one has the right to force him into the dairy business. Yet the most urgent need of the present time is the establishment of more co-operative dairy plants. Fifty such plants successfully operated in this state would not only prevent the importation of over a million dollars' worth of dairy products but they would foster such industries as poultry and particularly the production of pork. There is an excellent opportunity for thousands of families to acquire from 20 to 160 acres of irrigated land each and practice diversified farming. In 1901 one small farm of 119 acres in the Gallatin valley produced products to the value of \$2816, local market rates.

THE STATION AND THE AGRICULTURAL INDUSTRIES.

The Station is earnestly striving to better the condition of farming communities. It not only points the way to better things but its various departments are busily engaged in obtaining facts

and figures for the benefit of all those who depend on the soil or the range for a livelihood. In the matter of seeds Congress and the Department of Agriculture distribute seed which may or may not be adapted to Montana conditions. This Station on the other hand first tests all seeds and it is only after from three to five years of careful testing on the Station farm that a variety is recommended. Fully eighty per cent. of the total number of varieties tried are discarded as unsuitable to this state. There are about 150,000 acres in Montana seeded to oats. Two or three of the new varieties that are now being distributed by this Station to the farmers of the state will readily yield on an average five bushels per acre more than the varieties commonly raised. This increase in yield, on the acreage seeded, at current prices will produce a gross revenue of \$240,000 annually.

The efforts of the Station are also being expended in fostering those industries which have usually been regarded by our citizens as of secondary importance. Among these may be named the honey bee, poultry, fruit raising, the production of pork and the dairy products. All of these are worthy of careful attention and this Station hopes to become a factor in developing these infant industries.

In the broader phases of its work it is endeavoring to establish new industries, such as the production of beets and the manufacture of beet sugar, to reclaim large tracts of land that have been damaged by alkali and to convey water to irrigate land for the purpose of creating homes. The measurements of streams and ditches by this Station now run into the thousands and the data thus obtained afford valuable information concerning our natural water supply and the use that it subserves.

A decade ago the farmers of Gallatin valley used to summer fallow from twenty-five to fifty per cent. of their irrigated fields. Through the efforts of the Station and a few of the more intelligent and wide-awake farmers the summer fallowed area is being rapidly converted into clover and alfalfa. The fodder thus raised when fed to range stock yields returns of from \$15 to \$40 per acre. If the Gallatin valley farmers had continued to follow the advice of those who advocated summer fallowing on irrigated farms the loss to this county would now have amounted to over a quarter of a million dollars per annum.

THE DUAL FUNCTION OF THE EXPERIMENT STATION.

The function of the Station is two-fold. Regarded from the local and practical standpoint its chief function is to promote the agricultural industries of Montana. Its other field of work is quite as important. The Montana Experiment Station is only one of sixty in the United States. Fifty-four of these are maintained by congressional appropriations. The Stations bear in many respects the same relation to the Land Grant Colleges that the Carnegie Institution does to the higher universities of the country. They are organized and maintained for the purpose of carrying on investigations in scientific agriculture and applying the results in such a way as to benefit mankind. In this sense the function of the Station is world wide. The discovery of any scientific fact that is likely to exert an influence on the welfare of human beings receives the widest publicity. It is not intended that such knowledge should be confined to the state in which the discovery is made. Hence it follows that this Station is required to maintain the scientific features of its work although all the results may not have a direct bearing for the present at least on agriculture in this state.

NEEDS OF THE STATION.

Agricultural Department.—The live stock interests of Montana are and will continue to be the mainstay of her agriculture. In the equipment of the Agricultural College and Experiment Station of Montana this fact should be recognized and acted upon. Experiments with live stock and experiments relating to live stock should have prominent consideration. The growing of meat and wool, the breeding, growing and fattening of young stock and the production of milk and dairy products present problems that are pressing for solution. For animals and animal products which the Montana climate and Montana fodders enable her farmers to produce of the highest quality, and to produce most cheaply, the people yearly send mil-

lions of dollars out of the state. The Station is anxious to take up those lines of work on a scale commensurate with their importance to our farmers, but it cannot, out of its limited funds, provide the equipment necessary.

In carrying on experiments with steers or sheep, in winter feeding, the investment made returns in a few months to the Station funds, but with dairy cows and with breeding stock, the investment is practically a permanent one. For the dairy work at least 20 to 25 cows should be kept and for breeding work as many pure breds of different breeds are needed. For the work with sheep a grade and a pure bred flock are also needed and the same is true of swine.

The Iowa Experiment Station has purchased Montana range horses, shipped them to that state and fed them for the purpose of developing those horses into useful farm animals. The Iowa Station is anxious to show how the farmers of that state can most profitably use the coarse fodders of the farm and they find that the development of the Montana range horse was one of the profitable uses. The Montana farmer has as cheap grain and hay as his Iowa brother and the possibilities and methods of developing the Montana range horse into a useful animal for home or export use is a question the Montana Station would like to be able to investigate.

Live stock is needed to carry on the experiments outlined, but without buildings to properly house the breeding herds and flocks and the dairy cows, together with facilities for caring for the stock, and for conducting the experiments, it will not be advisable to get the live stock, or to experiment in these directions. The first thing needed, therefore, is suitable farm buildings. Among them a cattle breeding and dairy barn comes first. This barn should be large enough for present and prospective needs, and substantial and tasty in construction.

For the horses there is also needed a new barn, and associated with it a tool house and repair shop. Not far from this barn should be a wagon and implement shed.

For the sheep a barn arranged for a breeding and feeding flock is needed, and the breeding and feeding hogs have also to be provided for, as also the fattening steers.

In all of these buildings should be provided storage room for

the feeds needed by the animals for the winter and also ample conveniences for weighing both the animals and the feed used in the experimental work.

At present there is no place to properly care for the valuable experimental seeds and grains grown upon the farm. The work already done in introducing valuable varieties of grain into the state has much more than paid for a new seed barn and granary. Such a building is very much needed if the variety tests with grains are to be continued.

Botanical Department.—The chief need of the botanical department, like that of the entomological, is for more room and better facilities for work. Under the present conditions with every nook and corner full of cases and collections and every room filled with students it is impossible either to secure proper classification and storage or to separate in any way the work and collections of the College from those of the Station, while the head of the department has no room for his own private work or for the arrangement and display of the specimens upon which he may be studying. Some relief has been afforded by the grouping of all botanical classes in the last half year so as to leave the first free for Station work, but it is feared that there will not be room for all students who desire to take this work, as our resources were taxed to the utmost last year with 58 students entered, and the classes are now larger. A new building for the biological departments is imperative to accommodate their natural growth and afford facilities for class-rooms and laboratories, but in particular to give the Station officers adequate means for their work of economic and scientific research and for the secure storage of the collections upon which this research is based.

Entomological Department.—In the small rooms now occupied by the entomological department, which are used also for college classes, there is neither room nor facility for the entomological work demanded. Each succeeding year shows a marked increase in the demands from the State both for research work, and information concerning well known pests. Many of the pests of the older agricultural regions have found their way to Montana, and are rapidly multiplying and establishing themselves. Besides these there are

very many native species that are doing much damage to crops. In both these classes there is a great demand for the study of life histories, in order that suitable remedies may be worked out. For this purpose there is pressing need for room and equipment adapted for the work.

From the work on bees for the past two years it appears that there is a large field of usefulness in this line. Not only because of the returns in bee products, but also for the good accomplished by bees as cross fertilizers of plants, they should be much more generally kept in Montana than they are.

The experimental work in bees can be made self-supporting from the products sold; but we are in need of room for apiary work, such as, extracting and canning of honey; nailing and storing and painting of hives, etc. Not much room is needed but at present we are wholly without facilities for this work.

Horticultural Department.—The green houses we now have are no use at all for classwork, propagating plants, or growing the plants properly after being propagated, and there is no place in which to do the necessary work connected with the green house. The houses as they now stand are such that neither the temperature, moisture nor ventilation can be regulated, all of which is necessary to the best results.

The foundations, walls, sash bars and benches are fast decaying and falling to pieces, and within another year the houses will be available for no purpose whatever, unless an amount nearly equal to the first cost is expended in repairs. And to repair these houses is wholly impracticable, as they are not the style of houses wanted at this place, nor are they in a suitable location.

Plans and estimates of cost of thoroughly modern green houses have been received from the foremost horticultural builders of the United States, and such a structure as is wanted at this College, including a small building attached to be used as an office, classroom and general workroom or laboratory, can be built for about \$2,835.

This proposed house will be of iron frame-work throughout; the superstructure resting upon a solidly built brick wall, mounted

by a cast iron plate or sill. The benches (the first things ordinarily to decay) are made of iron; with tile bottoms, thus rendering them practically indestructible.

The minimum amount of wood consistent with the best results is used, thus greatly adding to the durability of the houses. Such a house will, in the ordinary course of events, last for an indefinite period with but little, if any repairs.

PUBLICATIONS.

The following Bulletins have been published during 1902:

No. 32	Eighth Annual Report.....	72 pages
No. 33	Sugar Beets in Montana, F. W. Traphagen....	15 pages
No. 34	Farmers' Weirs, S. Fortier.....	29 pages
No. 35	Report of Feeding Tests, R. S. Shaw.....	19 pages
No. 36	Forage Conditions of Central Montana, Frank A. Spragg.....	40 pages
No. 37	Pork Production in Montana, R. S. Shaw.....	10 pages
No. 38	Food Adulteration, F. W. Traphagen.....	24 pages
No. 39	Sheep Feeding in Montana, R. S. Shaw..	15 pages
No. 40	Root Crops in Montana, R. S. Shaw.....	20 pages
No. 41	Sugar Beets, (1902) F. W. Traphagen....	8 pages
No. 42	The Codling Moth, R. A. Cooley.....	18 pages

FARMERS' INSTITUTES.

In 1901, the seventh legislative assembly of Montana enacted a law providing for the holding of farmers' institutes and appropriating the sum of \$2,000 a year for that purpose. The directors of the board of administration for the past two years have been:

J. K. Toole, Governor of Montana.

T. C. Power, President of the Wool Growers' Association.

J. T. Brown, President of the Stock Growers' Association.

A. L. Stone, President of the Horticultural Society.

S. Fortier, Director Montana Experiment Station.

An organization was effected June 10, 1901, at which A. L. Stone was elected president and S. Fortier secretary and acting director.

During the winter of 1901 and 1902 institutes varying in length from one to three days were held in 17 counties of the state. The mode of procedure was as follows: When the dates for a series of institutes had been fixed letters were sent by the secretary to the editors of the local newspapers, to the business men of the towns and to the prominent farmers and stockmen in each county or district where an institute was to be held, notifying them of the fact and soliciting their co-operation. The newspaper men rendered valuable assistance in advertising the meetings, the merchants in many cases provided a suitable hall, while the farmers and stockmen manifested an interest by attending and taking part in the discussions.

In several of the counties visited no farmers' institutes had ever been held. The proceedings were, therefore, new to many and some difficulty was encountered in getting well informed and experienced men to take part. This difficulty has already been partly overcome. The nucleus of a local organization was formed in each county by the appointment of a standing committee. A number of counties have since effected a local organization and in future the meetings of the state board will have the co-operation of the county organizations.

The amount appropriated by the state was too small to permit the payment of salaries to anyone. There was no superintendent and the greater part of the work devolved on the officers of the Experiment Station. Notwithstanding the regular duties of each and the long distances traversed, the Station workers delivered during the winter 84 addresses at farmers' institutes. President Reid and several members of the College faculty also rendered valuable service.

The most valuable part of the proceedings of each farmers' institute was collected and compiled to form part of the first annual report. This report, which has recently been published, contains 292 pages of information of a practical nature that cannot but prove of value in bettering the condition of the agriculturist of Montana.

STATION STAFF.

Prof. R. S. Shaw resigned his position as agriculturist August 31, 1902, to accept a more lucrative position at the Michigan Agricultural College. He is now professor of agriculture and in charge of live stock experiments and the College and Station farm. Everyone connected with this Station regretted to have Mr. Shaw leave for he had proved himself to be a capable instructor, an efficient and painstaking investigator and an enthusiast in farmers' institute work.

The institution has been extremely fortunate, however, in securing the services of Prof. F. B. Linfield as his successor. Mr. Linfield was educated in the east but for more than ten years past he has been connected with the Agricultural College and Experiment Station of Utah. He is, in consequence, thoroughly familiar with western conditions. We believe that he has done more to develop the agricultural industries of Utah than any other officer who has ever been connected with its Experiment Station and we hope that he may soon become a potent factor in building up the infant industries of Montana in order that such products as butter, cheese, poultry and ham, which are now shipped in large quantities from Utah, may be produced by our own people.

Last July the horticultural department of the Station was strengthened by the appointment of Mr. R. W. Fisher, a graduate in horticulture of the University of Idaho, with the rank of assistant horticulturist. Mr. Fisher is a western man and understands the needs of the west in horticultural work and of the opportunities which it presents to develop this industry.

EXCHANGE LIST.

American Fertilizer, Philadelphia, Pa.
American Fancier, Johnstown, N. Y.
American Poultry Advocate, Syracuse, N. Y.
Avant Courier, Bozeman, Mont.
Beet Sugar Gazette, Chicago, Ill.
Belt Valley Times, Belt, Mont.
Billings Times, Billings, Mont.
Butte Inter Mountain, Butte, Mont.
Butcher's Advocate, New York, N. Y.
Carbon County Chronicle, Red Lodge, Mont.
Chicago Drover's Journal, Union Stock Yards, Chicago, Ill.
Chronicle, Bozeman, Mont.
Chicago Live Stock World, Chicago, Ill.
Chinook Opinion, Chinook, Mont.
Dillon Tribune, Dillon, Mont.
Daily Independent, Helena, Mont.
Elgin Dairy Report, Elgin, Ill.
Farm Poultry, Boston, Mass.
Fruit Grower and Farmer,
Farm, Field and Fireside, Monthly, Chicago, Ill.
Farmer Breeder, Sioux City, Iowa.
Farm Journal, Philadelphia, Pa.
Feather, Washington, D. C.
Farmers' Guide, Huntington, Ind.
Florist's Review, Chicago, Ill.
Farmers' Review, Chicago, Ill.
Gallatin County Republican, Bozeman, Mont.
Glendive Independent, Glendive, Mont.
Great Falls Weekly, Great Falls, Mont.
Gleanings in Bee Culture, Medina, Ohio.
Holstein Friesian, Brattleboro, Vt.
Home and Farm, Louisville, Ky.
• Horticultural Visitor, Kinmundy, Ill.
Irrigation Age, Chicago, Ill.
Inter Mountain Farmer, Salt Lake City, Utah.
Jersey Bulletin, Indianapolis, Ind.
Kansas Farmer, Topeka, Kan.
Livingston Post, Livingston, Mont.
Madisonian, Virginia City, Mont.
Modern Farmer, St. Joseph, Mo.
Milwaukee Weekly Journal, Milwaukee, Wis.
Mining and Scientific Press, San Francisco, Cal.

Montana Fruit Grower, Missoula, Mont.
National Stockman and Farmer, Helena, Mont.
National Farmer, Winona, Minn.
Northwestern Tribune, Stevensville, Mont.
New York Herald, New York, N. Y.
Northwest Poultry Journal, Salem, Ore.
Opportunity, St. Paul, Minn.
Ohio Farmer, Cleveland, Ohio.
Oregon Agriculturist, Portland, Ore.
Orange Judd Farmer, Chicago, Ill.
Plainsman, Plains, Mont.
Park and Cemetery and Landscape Gardening, Chicago, Ill.
Poultry Farmer, Des Moines, Iowa.
Poultry Herald, St. Paul, Minn.
Pacific Coast Financier's Monthly, San Jose, Cal.
Poultry Culture, Kansas City, Mo.
Rural New Yorker, New York, N. Y.
Reliable Poultry Journal, Quincy, Ill.
Rocky Mountain Husbandman, White Sulphur Springs, Mont.
Republic, St. Louis, Mo.
Semi-Weekly Missoulian, Missoula, Mont.
Sentinel, Boulder, Mont.
Strawberry Specialist, Kittrell, N. Carolina.
Stockman and Farmer, Belgrade, Mont.
Tribune Review, Butte, Mont.
Tribune, Great Falls, Mont.
Up-to-Date Farming and Gardening, Indianapolis, Ind.
Wisconsin Agriculturist, Racine, Wis.
Wallace's Farmer, Des Moines, Iowa.
World, Vancouver, B. C.
West Virginia Farm Review, Charleston, W. Va.
Western Fruit Journal, St. Joseph, Mo.
Weekly Chronicle, San Francisco, Cal.
Western Home Journal, Spokane, Wash.
Western Swine Breeder, Lincoln, Neb.
Western News, Libby, Mont.

S. FORTIER,

Director.

AGRICULTURAL DEPARTMENT.

R. S. SHAW, Agriculturist.

REPORT ON VARIETY TESTS OF GRAINS.

The following report contains the results of variety grain testing for the years 1899, 1900 and 1901. These same varieties were also tested during the season of 1898, but as it was required that they be grown under a combination of the Campbell method and the irrigation system the data secured from that year's work are not included in the figures given, because of the dissimilarity of the methods employed and the unsatisfactory results obtained. Many of these varieties were secured and grown prior to the time of the writer's connection with the Station.

DIFFICULTY IN SECURING UNIFORM RESULTS.

Where varieties of grain are grown under irrigation great difficulty is experienced in securing uniformity in the comparative results, no matter how carefully the work may be performed. The

Station farm, fortunately, is such that soil of uniform quality can be readily selected. The difficulty arises in irrigation; let this work be as skillfully and accurately performed as possible, and yet it is practically impossible to apply exactly the same quantity of water to each of a hundred or more plats. Most experimenters attach great importance to the yields, selecting the greatest yielder providing the quality will admit. Under our conditions less importance is attached to yield and selections are made rather from a combination of results, time required to mature, weight, and combined quality of grain and straw. As a result the varieties selected are not always the largest yielders.

METHODS FOLLOWED IN GRAIN TESTING.

Soil as nearly uniform as possible in composition and natural moisture content is chosen. The preparatory cultivation consists in moderately deep fall plowing. This is followed in the spring by thorough cultivation and cross cultivation with the spring tooth cultivator, after which the ground is graded and smoothed by means of a light harrow. The ground is then surveyed and staked off into plats of a given area, usually from one-fortieth to one-sixtieth of an acre with three feet between plats. The plats are generally made less than five feet in width to permit cutting in one swath by the binder. Before sowing the plats are marked off by means of a hand marker into drill rows nine inches apart, the two outer rows being four and one-half inches from the boundary lines.

The seed is selected by means of a grain grader; the one now in use is the "Eureka," manufactured at Lincoln, Nebraska. This machine selects according to the weight of the kernels, by means of a blast of air which passes through a shaft into which the grain drops at about the center. The plump, heavy kernels drop into the grain box below, while the lighter ones are carried over on the floor together with bits of straw, chaff and the large, light weed seeds. In selecting seed from the varieties fully one-third of the lighter grain is separated. After cleaning, sufficient grain for plat seeding is hand picked, to remove any foreign grains which may

be present, and the amount of seed for each plot is weighed out in about the same proportion as the required seedings for field crops. The seeds are then treated to destroy smut powers and afterward dried for sowing.

Sowing.—This work is performed by means of a hand garden seed drill, as it has been found almost impossible to put a given quantity of grain in a small plot by means of a large seeder. Owing to the difference in the size of kernels, smooth or rough coats, etc., the field drill cannot be set to measure accurately the amount of seed required for each plot, where a great number of varieties are following in succession.

Cultivation.—As soon as the variety grains are from four to six inches high a hand wheel cultivator is used, with the cutting knives, to clean out any weeds which may have started between the drill rows. Two interspaces are cultivated at each stroke of the wheel hoe which straddles every alternate row. While this gives the plot grain some advantage over the field crop, it prevents the growth of weeds almost entirely; this practice, even though the only cultivation applied, is one of the factors tending to produce average yields among the plots greater than those secured from field conditions.

Irrigation.—Before irrigating the spaces between the plots are run through with a one horse cultivator, carrying a shovel on each outside rear shank, which throws a lever up against the grain. The water is then turned in among the grain and is held there by the banks alongside, otherwise, the water would take its course along the unobstructed paths between the plots washing away the loose earth.

Harvesting.—From one-third to one-half the varieties have to be cradled and tied by hand because of differences in the dates of ripening and the impossibility of getting a machine to the plot. The balance is cut with the reaper which is followed by gleaners to prevent waste or any admixture.

Threshing.—The work is performed by means of a small separator with a 24 inch cylinder and 35 inch body. This machine is also used for the farm crops and has turned out as much as 900 bushels of barley in one day and 1400 of oats in another. For

plot threshing, the body of the machine is raised one and one-half inches above level in front to make the interior clean well and quickly; no small screens are used in which the grain would find a lodging place and there are no small weed seeds to separate; the cleaning is done by the use of large sieves and carefully regulated wind power. The cap beneath the screw which delivers the grain is removed and the grain allowed to drop in a box beneath. To prevent mixture the elevators are allowed to discharge on the ground and this material is cleaned up later and a proportionate share of the weight of this waste is added to each plot. No two varieties of the same kind go through the machine in succession, so that the subsequent cleaning can remove any admixture should there be a grain or two. The plots are brought to the machine tied in large sheets from which there can be no loss or mixing. Weights before and after threshing are recorded while the work is in progress.

This account of the detail work required in variety grain testing is given in the hope that some features of the work may be of practical value to private individuals, so many of whom secure small quantities of new grain from seedsmen for trial purposes, and in the handling of which difficulties are frequently encountered. We trust the results hereafter given will seem to justify the expenditure of time and energy required in placing new and improved varieties of grain in the hands of our farmers.

VARIETY WHEAT TESTS. Report on Varieties. Giving Averages for 1899, 1900 and 1901.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.	REMARKS.
	Bushels.	Pounds.	Pounds.	Days.	
1. Onyx.....	65.7	5191	59.	124	Soft, white, poor milling.
2. Opal	65.2	4549	59.	123	Soft, white, poor milling.
3. Chili.....	63.5	5149	60.6	123	Soft, white, best milling club.
4. Russian 2955.....	60.7	5340	61.7	121	Red, hard, good milling.
5. Hungarian Mountain.....	57.	4448	60.5	124	White, medium hard, coarse quality.
6. Nox.....	56.5	5155	60.5	122	Soft, white and clear.
7. California White.....	56.	4566	60.7	122	Soft, white, feed wheat.
8. Glyndons 113.....	55.4	5425	59.8	125	Red, medium hard milling.
9. Pringles Champion.....	54.8	4545	60.	116	Red, hard milling.
10. White Colorado.....	54.4	4728	62.	124	White, soft, feed wheat.
11. White Chaff.....	53.8	5299	59.8	123	White, soft, feed wheat.
12. Eldorado.....	53.4	5010	59.6	124	White, soft, seven head.
13. Glyndons 715.....	53.4	5734	60.	126	Red, hard milling.
14. Glyndons 676.....	53.2	4855	60.5	123	Red, medium hard milling.
15. Red Fife.....	52.5	4911	59.	127	Red, medium hard milling.
16. Kubanka	52.4	4373	63.3	123	Macaroni hard.
17. Glyndons 774	51.7	5792	59.5	124	Red, medium hard milling.
18. Junket	51.7	5593	60.4	123	Red, soft, large and coarse.
19. Glyndons 638.....	51.6	5240	60.5	124	Red, medium hard milling.
20. Bedfords Hungarian.....	51.4	5574	60.2	120	Red, medium hard milling.
21. Ladoga.....	51.2	3802	60.5	112	Red, hard, shatters badly.
22. McKissock's Fife.....	51.1	5247	60.8	123	Red, medium hard milling.
23. Glyndons 852.....	50.9	5542	60.8	121	Red, medium hard milling.
24. Wild Goose.....	50.9	4280	63.2	126	Macaroni, hard.
25. Glyndons 691.....	50.7	5320	61.	123	Red, hard, best milling.
26. Glyndons 768.....	50.7	4727	60.8	125	Red, medium hard milling.
27. Wellman's Fife.....	50.2	5200	60.	120	Red, soft.
28. Glyndons 135.....	49.3	4974	60.3	123	Red, medium hard milling.
29. Glyndons 650.....	47.8	4352	60.6	123	Red, hard, good milling.
30. Glyndons 692.....	47.5	5594	60.1	120	Red, hard, extra milling.

MONTANA EXPERIMENT STATION.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.		REMARKS.
	Bushels.	Pounds.	Pounds.	Days.	Days.	
31. Velvet Chaff.....	47.4	5616	58.7	122		Red, soft.
32. Glyndons 963.....	47.2	5098	60.1	121		Red, medium hard milling.
33. Glyndons 673.....	46.9	4827	60.2	122		Red, medium hard milling.
34. Bart Truneina.....	46.7	4142	62.7	115		Red, medium hard milling.
35. Glyndons 661.....	46.7	5780	60.	122		Red, hard, good milling.
36. Glyndons 675.....	45.8	4514	60.8	119		Red, medium hard milling.
37. Glyndons 758.....	45.6	4735	61.2	123		Red, hard, extra milling.
38. Virden.....	44.7	4022	60.6	118		Red, medium hard milling.
39. Deitz Red N. M. 39.....	42.7	4582	60.1	118		Red, medium hard milling.
40. Gold Drop.....	41.5	5090	59.3	117		Red, medium hard milling.
41. Blounts Hybrid.....	38.6	5753	60.8	124		Red, medium hard milling.
42. Club.....	36.6	4224	61.5	115		White, soft.

The following varieties of wheat were discontinued after the season of 1899.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.	REMARKS.
	Bushels.	Pounds.	Pounds.	Days.	
1. Amethyst.....	67.5	6870	59.	133	Poor milling and late.
2. Black Bearded Centennial	64.	5040	59.	133	" "
3. Bordeause N. M. 472.....	64.	7680	59.	133	" "
4. Gneiss.....	63.5	4710	59.	133	" "
5. Gypsum.....	58.	5490	58.	133	" "
6. Glyndons 773.....	47.5	5310	59.6	133	" "
7. Glyndons 761.....	47.5	6030	59.9	133	" "
8. Glyndons 750.....	45.5	6090	54.4	133	" "
9. Glyndons 748.....	45.	5520	55.6	133	" "
10. Glyndons 818.....	43.	5880	58.8	133	" "
11. Summer Cob.....	41.	4260	59.5	133	" "
12. Silver Fife.....	41.	4740	59.	129	" "
13. Minnesota Fife.....	40.	5040	60.	133	" "
14. Snow Ball.....	40.	6690	58.1	127	" "
15. White Sq. Head Russian.	39.	4380	60.	130	" "
16. Blue Stem.....	38.	3600	60.4	127	" "
17. Auger's Canadian.....	35.5	4170	60.4	127	" "
18. Powers Fife.....	35.	4200	58.8	127	" "
19. China Tea.....	32.	6090	60.	127	" "
20. White Fife.....	31.	4140	60.	133	" "
21. Sutherlin.....	31.	3360	60.	133	" "

Owing to the changes which are likely to occur because of new environments it is not possible to determine the merits of an imported variety with any degree of accuracy in less than three years. Changes most frequently occur in texture of grain, yield and color.

The following varieties of wheat were chosen on the basis of quality and yield and sown in 1901 to increase the stock for co-operative purposes.

1	Kubanka,	.221	acre sown,	yield 13 bu. 58 lbs. or 63.19 bu. per acre
2	Wild Goose,	.307	" " " 14 "	" 45.6 " " "
3	Russian 2995,	.309	" " " 12 " 55 "	" 41.8 " " "
4	Red Fife,	.306	" " " 12 " 45 "	" 41.66 " " "

Kubanka and Wild Goose, though macaroni wheats, were grown under irrigation without any apparent softening of the kernel. Russian 2995 was supplied by the Department of Agriculture in '99 and is one of the most promising milling wheats.

VARIETY OAT TESTS. Report on Varieties, Giving Averages for 1899, 1900 and 1901.

NAME.	Grain Per Acre.		Straw Per Acre.		Weight Per Bushel		Maturity.		REMARKS.
	Bushels.		Pounds.		Pounds.		Days.		
1. Swedish Select 2788.....	100.3		3954		43.5		110		Strong straw, heavy yield, good quality, early.
2. White Swede.....	98.1		4136		38.8		113		" " " " " "
3. White Danish.....	91.8		3784		39.7		112		" " " " " "
4. Am. Banner.....	91.3		3610		40.7		111		" " " " " "
5. Am White	90.7		4490		43.9		103		Early and good but heavy hulled,
6. Great Northern.....	88.7		4009		40.1		111		Medium kernel and medium hull.
7. Am. Beauty.....	87.6		4070		40.6		112		Good straw and grain, hull medium.
8. Mogheda	87.5		3835		40.		112		" " " " soft hull.
9. Nameless Beauty.....	86.5		4035		42.9		107		" " " " early
10. Progress.	86.5		3764		40.4		113		" " " " hull medium.
11. Blands White.....	86.3		4347		40.		109		" " " " "
12. Impd. American.....	86.3		3900		40.3		110		" " " " "
13. Early Everett.....	86.		3825		40.8		110		" " " " more than medium
14. Race Horse.....	84.3		3809		43.		108		" " hull too coarse.
15. Wide Awake.....	81.1		3904		41.2		110		" " and grain.
16. Victoria.....	80.8		4294		42.2		107		" " " "
17. Badger Queen.....	77.		3814		43.3		109		" " grain heavy hulled.
18. Scotch.....	77.		4077		40.6		104		" " " "
19. White Wonder.....	73.3		4337		42.1		104		" " " "

The following varieties of oats were discontinued after the season of 1900.

NAME.	Grain, Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.	REMARKS.
	Bushels.	Pounds.	Pounds.	Days.	
1. Archangel	93.7	3790	39.5	110	Good, in circulation.
2. Black Tartarian.....	91.9	3804	38.2	111	Black, unmarketable.
3. Siberian	89.	3933	38.1	111	Grain yellow color.
4. Poland White.....	87.7	3298	40.4	112	Good, in circulation.
5. Canadian White.....	86.	4641	37.2	114	Light weight.
6. Yellow Giant	85.3	3319	40.2	109	Weak straw.
7. Henderson's Clydesdale..	84.	3400	39.2	112	Small, light grain with awns.
8. Am Best.....	82.9	3186	39.9	110	Short straw
9. Joannette.....	81.8	3793	39.	111	Good but black and unmarketable.
10. White Schonen.....	81.2	3264	39.5	112	Weak straw.
11. Bavarian.....	80.7	3238	37.8	111	Light Grain and straw.
12. Square Head.....	68.4	3202	34.4	112	Very light.
13. Chinese Hulless	43.7	2408	50.	113	Poor yielder.

The following varieties of oats were discontinued after the season of 1899.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.		REMARKS.
	Bushels.	Pounds.	Pounds.	Days.		
1. Giant Yellow.....	84.7	4080	35.4	124		Heavy growth, late, light grain.
2. Nebraska.....	77.6	3260	36.6	122		Late.
3. Bonanza.....	75.	4020	39.7	124		Late.
4. Black Prolific.....	75.	3210	41.5	120		Black, unmarketable.
5. Prize Cluster.....	73.2	2490	41.4	121		Late.
6. Russian 2800.....	71.4	3810	43.	120		Similar to 2788.
7. Golden Giant.....	60.	4440	38.2	120		Late.
8. Giant French.....	60.	2460	37.8	120		Small and late.
9. White Maine.....	57.3	3210	40.7	120		Late
10. Lincoln.....	52.	4410	43.	111		

Varities of oats introduced 1901.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.		REMARKS.
	Bushels.	Pounds.	Pounds.	Days.		
1. Salzer's Big Four.....	129.	5181	31.	.....		Small grain, good quality.
2. Irish Victor.....	126.3	5184.	38.5	.....		Medium quality.
3. Alaska.....	104.6	4389	37.8	.....		Medium size and hull.
4. Michigan Wonder.....	94.2	5478	37.8	.....		Small and medium.
5. Ternia (Finland).....	90.5	4422	35.7	.....		Good but black.
6. Early Champion.....	82.9	4026	35.	.....		Small all hull.

Four varieties of oats were selected and increased with the following results under field culture:

Nameless Beauty.....	yield 79.9 bushels per acre
American White.....	" 79.8 " " "
Poland White.....	" 79.8 " " "
White Wonder.....	" 85.3 " " "

These oats were selected because of large yield, strong, stiff straw and heavy, plump grain with thin hulls. Swedish Select 2788 which yielded 110 bushels per acre in '99 was also grown in field lots for circulation. During the spring of '91 215 bushels of Swedish Select and 129 bushels of Nameless Beauty oats were put in the hands of farmers for seed, the past season 218 bushels of Swedish Select and 847 bushels of Nameless Beauty oats were sent out for seed. These varieties were started from a pound or two of seed four or five years ago.

BARLEY VARIETY TESTS. Report on Variety Tests for 1899, 1900 and 1901.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel.	Maturity.	REMARKS.
	Bushels.	Pounds.	Pounds.	Days.	
1. Goldenthorpe	71.4	3122	51.5	109	2 rowed, excellent brewing.
2. New Zealand	69.9	4102	52.5	107	" " " "
3. Mandscheuri.	67.6	3506	52.	106	" " " " good brewing.
4. Highland Scotch	60.6	3930	51.	112	" " " " " "
5. Manshury.	59.9	3788	49.8	97	6 " " " shatters badly.
6. California Prolific.	59.5	4116	52.	103	" " " " " "
7. Chevalier	58.5	3485	51.9	103	" " " " excellent brewing.
8. Improved Cheyenne	58.4	3658	51.9	103	" " " " " "
9. Italian	58.1	2658	52.	99	" " " " good brewing
10. Manhattan	55.4	4183	51.6	104	" " " " " "
11. Champion.	53	3310	52.2	99	" " " " " "
12. Kuma Kulla.	52.3	4040	51.4	101	" " " " " "
13. Six Rowed	52.2	3098	47.5	105	8 " " " " " "
14. Berkley	50.7	3161	50.3	98	2 " " " " " "
15. King.	49.6	3119	48.7	96	4 " " " " " "
16. Oderbrucker	45.7	2913	51.8	98	6 " " " " " "
17. Success	43.2	2965	49.5	93	" " " " " ty.

BARLEY VARIETY TESTS.—HULLESS BARLEYS. Report on Variety Tests for 1899, 1900 and 1901.

NAME.	Grain Per Acre.	Straw Per Acre.	Weight Per Bushel	Maturity.	REMARKS.
	Bushels.	Pounds.	Pounds.	Days.	
1. Black Hulless.....	56.8	2330	64.	99	
2. New White Hulless.....	55.3	2872	65.	102	
3. Guy Male.....	55.2	2443	63.5	99	
4. Delnoote.....	54.6	3019	63.4	99	
5. Winnipeg	49.7	3433	62.	100	
6. Smooth Hulless.....	47.8	2836	63.4	98	
7. Hungarian	39.9	2889	61.	100	
8. Nepaul	33.8	2643	59.7	96	

BARLEYS OBTAINED FROM THE DEPT. OF AGRICULTURE 1901.

1	Barley No. 5473,	.167	ac. sown,	yield 17 bu. 1 lb. or 101.9 bu per ac.
2	Princess Kom 5472,	.143	" " " "	10 " 36 lbs. or 75.1 bu. per ac.
3	Barley 5590,	.154	" " " "	11 " 16 " " 73.6 " " "
4	Sianskolskom 5474,	.161	" " " "	11 " 14 " " 70.1 " " "
5	Barley 5591,	.169	" " " "	9 " 2 " " 53.5 " " "
6	Barley 5592,	.171	" " " "	7 " 44 " " 46.3 " " "
7	Bavarian,	.241	" " " "	9 " 26 " " 30.5 " " "

These barleys were grown under extremely favorable conditions and one of the yields in particular is enormous. These results, however, cannot be relied upon and two successive years' trial will be necessary in order to make exact determinations. Most of these new varieties are early sorts.

Of the hulless barleys, New White and Smooth are little different either in growth or quality. They are both preferable to the Black Hulless which produces a profusion of long awns, rendering the straw dangerous to feed. The straw of the New White and Smooth Hulless barleys makes good feed, being leafy and somewhat soft.

Of the brewing barleys none give more satisfactory results in field culture than the Chevalier, Goldenthorpe, New Zealand and Mandscheuri, all of which are two rowed varieties bearing a striking similarity. The Manshury, a six row variety, yields a large quantity of grain of good quality but the straw breaks easily, allowing the head to drop and large quantities of the grain are lost in the process of harvesting.

REPORT ON VARIETY TESTS FOR SEASON OF 1902.

F. B. LINFIELD, Agriculturist.

To bring the report of Prof. Shaw's work up to date, the results with the small grain plats for 1902 are appended to his report. To permit of a comparison of the yields with Prof. Shaw's report for the years 1899, 1900 and 1901 the average yields for those years are placed in one column headed "1st report," and the yields for the season 1902 placed in the next column. It

will be noticed that both the yield of grain and of straw are very much larger for the year 1902 than for the previous three years, for all kinds of grain. The order of the yields is also changed somewhat though in the main the varieties which gave large yields for the three years are also near the top for 1902.

For the season of 1902 the yields of wheat range from 77 bushels per acre to 29 bushels per acre, but this latter yield was the only one below 50 bushels per acre. These results are certainly very good even for small plats.

The yield of straw for the season of 1902 is also large, viz.: three to five tons per acre, while the total acre crop ranges from four to seven tons.

Not much reliance can be placed on the "days to mature" for the season of 1902 as the date in the record refers to when the crop was cut, and much of the grain was over ripe. Neither Prof. Shaw nor myself had charge of the work at this time.

The yields of oats as given in Prof. Shaw's report are remarkable but for the season of 1902 are almost incredible to a stranger in Gallatin valley. The range is from 174 bushels per acre down to 90 bushels per acre at 32 pounds per bushel. I could scarcely credit this large yield even for small experimental plats, but after measuring the plats and again carefully weighing the grain, such are the results. The Early Everett oats yielded 174 bushels per acre. On a plat of one-sixth of an acre the yield was 93 pounds of oats, or nearly three bushels at 32 pounds per bushel. A measured bushel of these oats, however, weighs over 40 pounds, but in this record the standard Montana bushel of 32 pounds is used.

The yield of straw per acre ranges from $2\frac{1}{2}$ to nearly $5\frac{1}{2}$ tons and the total crop from 4 to 7 tons per acre. With oats as with wheat the number of days required to mature for the season of 1902 is not reliable, as the oats were over ripe when cut.

For the summer of 1902 the yield of barley on the experiment plats ranged from 29 to 96.8 bushels per acre. The varieties that gave the best average yield for the three years are not far from the best yielders for 1902. The yield of straw and of the total crop per acre is, as was to be expected, much below that of the wheat and oats. The comments of Prof. Shaw on the quality of these varieties of grain will apply to the season of 1902 as well as for the three years he reports upon.

VARIETY TESTS OF WHEAT.

Order of Yield.		NAME.	Grain Per Acre		Straw Per Acre		Days to Mature	
First Report	Season of 1902.		First Report.	Season of 1902.	First Report.	Season of 1902.	First Report	Season of 1902.
			Bushels.	Bushels.	Pounds.	Pounds.	Days.	Days.
16	4	Glyndons 135.....	49.3	65.5	4974	7770	123	129
21	16	" 673.....	46.9	63.	4827	8220	122	129
17	12	" 650.....	47.8	65.	4352	9300	123	129
23	7	" 675.....	45.8	67.	4514	9480	119	129
24	18	" 758.....	45.6	59.	4022	7860	118	129
18	15	" 692.....	47.5	63.25	5594	8505	120	129
5	6	" 712.....	53.4	69.	5734	7920	126	129
14	8	" 691.....	50.7	66.5	5320	9210	123	129
13	17	" 852.....	50.9	62.	5542	9180	121	129
9	5	" 774.....	51.7	70.5	5792	9270	124	129
14	4	" 768.....	50.7	72.5	4727	9750	125	129
6	6	" 676.....	53.2	69.	4855	9660	123	129
22	10	" 661.....	46.7	65.75	5780	9375	122	129
10	13	" 638.....	51.6	64.5	5240	8430	124	129
20	13	" 963.....	47.2	64.5	5098	6990	121	129
13	9	Wild Goose.....	50.9	66.	4280	8280	126	124
19	22	Velvet Chaff.....	47.4	53.	5616	7380	122	129
3	1	Pringles Champion..	54.8	77.	4545	8580	116	129
25	16	Deets Red N. M. 39..	42.7	63.	4582	8820	118	129
11	11	Bedford's Hungarian	51.4	65.5	5574	8310	120	129
12	19	McKissocks Fife....	51.1	58.	5247	8220	123	129
22	22	Bart Triminia.....	46.7	53.	4142	6660	115	132
5	3	Eldorado.....	53.4	75.5	5010	8670	124	124
26	20	Gold Drop Wheat...	41.5	57.	5090	7920	117	129
15	4	Wellman's Fife....	50.2	72.5	5200	10110	120	132
12	23	Lodoga.....	51.2	29.	3802	7680	112	124
8	2	Kubanka.....	52.4	76.5	4373	10050	123	125
2	21	Russian 2955.....	60.7	55.	5340	8700	121	126
27	19	Blounts Hybrid....	38.6	58.	5753	10800	124	132
7	14	Red Fife.....	52.5	64.	4911	10080	127	132
4	13	White Chaff.....	53.8	64.5	5299	9150	123	131
1	13	Chili.....	63.5	64.5	5149	9930	123	132
..	12	Battons Blue Stem..	....	65.	....	9300	...	132

VARIETY TESTS OF OATS.

Order of Yield.		NAME.	Grain Per Acre.		Straw Per Acre.		Days to Mature	
First Report	Season of 1902.		First Report.*	Season of 1902.	First Report.	Season of 1902.	First Report	Season of 1902.
			Bushels.	Bushels.	Pounds.	Pounds.	Days.	Days.
6	4	Improved American.	94.4	165.	3900	8820	110	126
5	7	Mogheda.....	95.7	146.7	3835	10725	112	127
9	14	Scotch.....	84.2	124.6	4077	8250	104	127
9	13	Badger Queen.....	84.2	126.5	3814	7950	109	127
2	15	White Danish.....	100.4	118.1	3784	10620	112	127
1	8	White Swede.....	107.3	146.2	4136	9120	113	127
6	5	Blands White.....	94.4	155.6	4347	9300	109	127
5	12	American Beauty....	95.7	130.7	4070	9615	112	124
4	10	Great Northern.....	97.	134.	4009	8310	111	124
3	11	American White.....	99.2	131.2	4490	7800	103	123
6	3	Progress.....	94.6	166.8	3764	8940	113	129
8	2	Wide Awake.....	88.7	172.5	3904	8760	110	124
7	1	Early Everett.....	94.1	174.3	3825	8100	110	122
..	18	Victoria B.....	.....	90.	..	5220	...	122
..	17	Michigan Wonder...	.....	100.3	....	9690	...	128
..	9	Salzers Big Four....	.....	136.8	....	10620	...	129
..	14	Archangel.....	.....	124.6	....	8910	...	130
..	16	Alaska.....	.....	105.	....	6300	...	122
..	6	Irish Victor.....	.....	154.8	....	7050	...	124

*NOTE—Prof. Shaw took 35 pounds as the weight of a standard bushel of oats. The Montana standard is 32 pounds per bushel, the result as given in Prof. Shaw's report are recalculated on this basis.

VARIETY TESTS OF BARLEY.

Order of Yield.		NAME.	Grain Per Acre.		Straw Per Acre.		Days to Mature	
First Report	Season of 1902.		First Report.	Season of 1902.	First Report.	Season of 1902.	First Report	Season of 1902.
			Bushels.	Bushels.	Pounds.	Pounds.	Days.	Days.
9	7	Manhattan.....	54.4	80.	4183	5760	104	121
12	18	Berkley.....	50.7	40.31	3460	4965	98	121
14	20	Hungarian.....	39.9	29.37	2889	4110	100	124
3	6	Mandscheuri.....	67.6	81.87	3508	6870	106	120
10	8	Champion.....	53.	75.9	3310	7215	99	121
7	3	Italian.....	58.1	90.	2658	6180	99	120
13	5	Winnipeg.....	49.7	82.5	3433	5520	100	119
2	2	New Zealand.....	69.9	93.75	4102	7200	107	120
9	9	Delnorte.....	54.6	75.	3019	6240	99	121
8	1	Guy Male.....	55.2	96.87	2443	5550	99	117
6	5	Improved Cheyenne.	58.4	82.5	3658	6240	103	119
5	5	California Prolific...	59.5	82.5	4116	5340	103	118
4	19	Manshury.....	59.9	36.25	3788	3480	97	118
1	13	Goldenthorpe.....	71.4	70.	3122	4740	109	118
6	4	Chevalier.....	58.5	88.43	3485	5655	103	118
11	14	Kinna Kulla.....	52.3	68.12	4040	6630	101	120
..	12	Princess Kane 5472...	....	70.9	....	5895	...	120
..	11	Chevalier 5473.....	....	71.8	....	4650	...	122
..	16	Sianskolskom 5474...	....	56.25	....	5100	...	121
..	11	Barley 5591.....	....	73.75	....	5460	...	120
..	15	Nepbant.....	....	59.06	....	4365	...	123
..	6	Bavarian.....	....	81.87	....	6870	...	119
..	17	Barley 5590.....	....	45.9	....	5115	...	119
..	14	Barley 5592.....	....	68.12	....	6630	...	119

POTATOES.

The following varieties of potatoes have been tested on the same basis for three consecutive years, though many of them had been grown on the farm prior to the season of 1899. In determining the values of each variety the yield, percentage of marketable potatoes, appearance, cooking qualities, and time required to mature have all been considered. Actual value cannot be determined from the size of the yield as many of the largest yielders contain a large quantity of both small and large rough potatoes, which decrease the percentage of useful ones. As a rule white rather than red potatoes find an easier sale on the markets. Potatoes with flesh other than white or cream color are not desirable. Those with a reddish tinge beneath the surface at the seed end are particularly objectionable. The Experiment Station is indebted to Miss Harkins, professor of Domestic Science, for the report on cooking qualities, without which it would have been difficult to learn the actual value of the varieties. The notes referring to the waste indicate whether the variety is smooth, thick or thin skinned, and with or without deep set eyes.

At one time no less than 67 varieties were under test, but many were discarded because of some undesirable qualities, but chiefly because of being poor keepers during the storage season.

The tests were made in small plots of a given area in which a given number of sets were planted by hand and account taken of blanks where sets failed to grow.

Excessive irrigation will delay the maturity of even the earliest sorts and prevent ripening. One irrigation as potatoes begin to bloom gave the best results.

POTATO VARIETY TESTS.—Report on Variety Tests for 1899, 1900 and 1901.

NAME.	Yield per Acre.	Per Cent Marketable.	Color.	Color of Flesh.	Cooking Quality.	Waste.	Maturity.
	Bushels.						
1. Montana Beauty.....	488.	80.6	white	yellow	rather poor, soggy	none	late
2. White Elephant.....	478.9	66.9	white	white with dark spots	mealy, good flavor	none	late
3. Chas. Downing.....	475.8	80.5	white	white	mealy, poor flavor	none	late
4. Rural N. Y. No. 2....	470.8	88.2	white	white	mealy, good flavor	none	medium
5. Carmens No. 1.....	450	63.	red	cream color	good flavor	little	medium
6. Vanguard.....	449.3	87.3	white	white	mealy, poor flavor	some	late
7. Beauty of Hebron....	448.9	71.1	flesh color	yellow	medium	none	medium
8. Lees Favorite.....	448.7	83.2	white	white	very best	none	medium
9. Irish Daisy.....	447.4	80.9	white	cream color	medium	some	medium
10. Leviathan.....	444.9	71.9	red	white	poor, soggy	much	late
11. Burpees Superior....	440.5	75.	white	white	good flavor, soggy	some	medium
12. World's Fair.....	435.7	78.5	white	cream color	mealy, dry, good	none	medium
13. Wylie.....	426.8	71.	white	yellow	poor flavor	none	medium
14. White Star.....	426.6	66.7	white	green	poor, soggy	much	medium
15. Lightning Express....	424.4	81.4	white	white	good	none	late
16. Irish Cobbler.....	422	87.3	white	white	good, mealy	some	medium
17. Henderson's No. 1....	412.7	73.3	pink	yellow	soggy	little	medium
18. Sandy Knowles Seedling	406.7	84.2	red	white	mealy	little	medium
19. Reeds 85.....	405.6	82.	white	reddish	or	none	medium
20. Wise Seedling.....	405.	68.2	pink	white	or, mealy	some	medium
21. Mammoth Pearl.....	404.4	75.5	white	white	aly	none	late
22. Early Norther.....	403.6	74.7	red	white	or, mealy	some	medium
23. Oregon Pedigree.....	401	82.6	white	white	or	none	late
24. Crown Jewel.....	384.1	61.9	white	white	or	none	late
25. Oregon Pearl.....	379.9	74.9	white	yellow	aly	none	medium
26. Snow Drop.....	379.	70	white	yellow	or, soggy	none	medium
27. Burpees Extra Early..	370.3	73.2	red	dark	flavor	none	early
28. State of Maine.....	368.3	64.5	white	white	red	none	late
29. Delaware.....	366.8	76.2	white	cream	good	slight	medium

VARIETY POTATO TESTS.—Continued.

Per Cent Market- able.	Color.	Color of Flesh.	Cooking Quality.	Waste.	Maturity.
68.5	red	dark	poor flavor, soggy	little	late
65.	white	white	good flavor	little	medium
80.4	white	yellow	good flavor	much	medium
80.7	white	yellow	poor flavor, soggy	little	late
80.5	white	cream	good quality	much	late
84.8	pink	white	medium quality	none	ex. early
75.1	red	white	good, mealy	none	medium
79.	red	yellow	good flavor, soggy	some	late
71.7	white	yellow	good flavor, mealy	none	medium
59.2	pink	white	fair flavor	slight	medium
83.1	white	white	good flavor, mealy	none	medium
78.6	pink.	white	fair flavor, mealy	none	ex. early
77.1	white	yellow	good flavor	none	medium
68.6	pink	yellow	good flavor, mealy	little	medium

Four classes as regards maturity have been made, late, medium, early, extra early. Of these there are a few classified as late which can be grown only in favored parts of the state, as they fail to mature, as indicated by the soggy condition when cooked. The medium varieties should not be grown above an altitude of 4,750 feet but the early and extra early sorts may be grown up to at least 6,500 feet. In general the later the variety or the longer it requires to develop the greater will be the yield; the extra early sorts being very small yielders.

The following varieties which were selected for the field crop of 1900 gave these results:

		yield at rate of 341 bushels per acre			
1	White Maine,	Late			
2	Lee's Favorite,	Medium	"	"	293
3	Early Oxford,	Medium	"	"	296
4	Acme,	Extra Early	"	"	270
5	Oregon Pearl,	Medium	"	"	270
6	Six Week's Market,	Extra Early	"	"	261
7	American Wonder,	Medium	"	"	260
8	Snow Drop,	Medium	"	"	240
9	Early Vaughan,	Extra Early	"	"	232
10	Rural N. Y., No. 2.	Medium	"	"	173
11	Early Ohio,	Early	"	"	144

Some of these varieties were transferred from the plot to field tests before the close of plot tests because of a knowledge of their previous performance. The yields above given were greatly reduced by inability to secure water for irrigation until ten days later than the proper time.

The varieties planted during May, 1902, for the field crop are Freeman, Early Ohio, Six Week's Market, Rural New Yorker No. 2, State of Maine, Burpee's Extra Early, Prize Taker, and Sweet Home.

The following early varieties were introduced in 1900 and 1901: Vigorosa, Kaiser Krone, Sweet Home, Early Michigan, Bovee, German Early Rose, Bliss Triumph, Pat's Choice, White Ohio, Peach Blow, Pride of the South, and Lakeside Champion. Notwithstanding the adverse conditions under which these were grown in 1901, their average per acre was 210 bushels with 84 per cent marketable; all are early.

CO-OPERATION OF THE MONTANA EXPERIMENT STATION WITH THE FARMERS OF THE STATE.

R. S. SHAW, Agriculturist.

The work of an Experiment Station particularly in a new country is not well understood, evidence of which is found in the written and verbal questions which are put to the workers of such an institution. Though some investigations are constantly in progress with the object of securing scientific results which can be given a practical application, still, the greater portion of the work of a new institution is as a rule of a very practical nature intended to produce results of direct benefit to the farmer, stockman and fruitgrower. It is with this object in view that a co-operative system has been established by the Experiment Station.

The peculiar and greatly varied agricultural conditions found within this state require an extension of the work of the Station beyond the limits not only of its own farm but also of the valley in which it is situated. The state is one of communities each possessed of a different variety of soil, climatic conditions, altitude, etc. As a result crop production in each is more or less different as well as the common interests of the people. Because of these conditions it is not possible to secure results on the Station farm in the Gallatin valley which will be of service throughout the state to the crop producer. In order to overcome the conditions mentioned and widen the usefulness of the institution a co-operative system was established in 1901, the chief object of which is to aid the farmer and stockman in the production of grain, grass, forage crops, root crops and potatoes. Varieties of these crops are secured by the Station from every possible source and tested in small plats for three or more consecutive years, after which those of special merit are selected and increased for co-operative purposes and for sale. A full description of this work will be given in the annual report for the year ending June 30th, 1902. Those varieties which give greatest promise of usefulness on the Station farm are sent throughout the state. While yield, quality, etc. are important factors in determining the value of a variety, care is taken to ascertain

the time required to mature. For instance the earliest barley grown will mature in 92 days, the latest one requiring 119 days. This variance in maturing permits suitable selections of barley for a great variety of conditions under a wide range of altitude. The ability of certain varieties to resist drouth more than others, also effects the selection for a given locality known to have peculiar conditions. In sending out seeds care is taken to select those best suited to the conditions existing in the locality where they are to be grown.

During the spring of 1902 this co-operative system has been extended to the following counties of the state with the number of co-operators indicated by the accompanying figures, viz.: Beaverhead 5, Broadwater 3, Carbon 2, Cascade 8, Choteau 9, Custer 2, Deer Lodge 1, Fergus 1, Flathead 2, Gallatin 8, Lewis and Clarke 1, Madison 1, Missoula 1, Ravalli 5, Sweet Grass 3, Teton 1. Thus there are 53 co-operators in 16 counties of the state. The only reason why every county is not represented is because we were unable to meet farmers in those counties and arrange for the work. By request, a few lots of oats were sent to Alaska, Kansas and Minnesota. The United States Department of Agriculture, Washington, D. C., secured 10 bushels of Montana grown Swedish Select oats from us for distribution.

In all 117 trial lots of various combinations were sent out, requiring the following materials, viz: oats, 2,635 pounds; wheat, 150 pounds; barley, 189 pounds; peas, 665 pounds; speltz, 131 pounds; spring rye, 45 pounds; vetch, 15 pounds; alfalfa, 60 pounds; rape, 20 pounds; potatoes, 2,205 pounds.

These lots were furnished free of charge under the condition that the co-operator pay transportation charges and report the results after harvest. Fifteen trial lots of maccaroni wheat were supplied to our co-operators by M. A. Carleton, of the Department of Agriculture, by special arrangement. The grower is permitted to retain the product for his own use. Sufficient seed of each sort is supplied so that the co-operator can produce sufficient to seed an average sized farm after the second year in case he is successful with some particular variety. By this method good varieties are introduced and the reports coming to one central point enables the Station to determine what varieties are best suited to a given lo-

cality and keep a record of the sources of seed supply.

Some gratifying results have already been secured from this work. The writer recently passed a forty acre field of New White Hulless barley in the Gallatin valley, the seed of which came from two pounds which this Station secured for trial a few years ago. From two pounds of White Russian or Swedish Select oats secured in 1899, 215 bushels were sent out in 1901, and 220 bushels in 1902. In the same way a trial sample of Nameless Beauty oats was increased to about 1,400 bushels in 1901.

Where large quantities of improved grains are desired by farmers of the state they can be purchased at the current market prices, though in the case of a limited stock the amount of each individual purchase is limited in order to permit a larger number to secure grain for a start.

The following grains were sold to Montana farmers for seed in the spring of 1902: oats, 34,298 pounds; peas, 5,230 pounds; wheat, 1,887 pounds; barley, 1,090 pounds, and potatoes, 2,305 pounds. In most cases reports from these are also secured.

Of the 4,013 bushels of grain produced on a part of the Station farm in 1901 a portion was used as above described, a large quantity was required in the fattening of the two carloads of stock, one of sheep and one of lambs, some was used for the seeding of 1902 and the balance for the maintenance of work horses, dairy cows, pigs and chickens. No purchases were made.

A report from co-operative work in Cascade county during 1901 gives the following: "The one-half bushel of White Russian oats I got last spring yielded at the rate of 100 bushels per acre. The White Maine and Early Six Weeks potatoes gave the best satisfaction of any potatoes I ever raised for quality and yield. The mummy peas did well. I will have a fine lot of seed this spring to sow from your samples."

Another report from Ravalli county says: "The White Russian oats received from your establishment last spring were sown April 15th, irrigated June 20th, harvested August 15th; yield 100 bushels per acre. Soil gravelly loam."

Including the 53 co-operators there were 86 farmers in the state of Montana growing grain from Experiment Station seed during the season of 1902.

PRODUCTS OF MONTANA IRRIGATED LANDS.

Questions of irrigation in connection with the reclaiming of arid lands of the West have been receiving much attention of late. While it is generally conceded that these lands are wonderfully productive when placed under irrigation, still very little data have been secured to show in a definite way the possibilities of a given area under crop production. Partial reports have frequently been given stating the yield of individual crops of alfalfa, clover, grain, potatoes and other roots and cereals, but we know of no report by which the total yield of a diversified crop from a given area has been placed on record.

In following out the many lines of work to which the Montana Experiment Station farm is now entirely devoted it became a comparatively easy matter to determine the total products from a given area under cultivation, where irrigation was applied. In the varied work followed in the methods of cultivation, testing of farm crops and irrigation in its relation to this work, it was necessary to make a careful survey of the actual crop area and also a complete record of the absolute and comparative yields.

The Station farm consists of 160 acres, but this is not all available for the production of farm crops. A portion is used by the Horticultural Department, ten or more acres consist of seepy land too wet to cultivate, while a few acres comprise a rocky draw. Some land is also occupied for building sites and feed yards. A small area of the farm is also taken up by two roads which intersect it at right angles. While there is considerable so-called waste land on the farm, this area is being diminished every year as the means become available to reclaim it.

During the summer of 1901 118.81 acres of the Station farm were used in the production of farm crops, as follows: Grain crops, 72.32 acres; clover, 43.61 acres; potatoes and roots, 2.88 acres. These areas include both the farm crops and the grain plats. The total yield of the farm crops secured from the 118.81 acres is as follows:

CEREALS.

	BUSHELS.	POUNDS.
Barley	1,482	36
Wheat.....	380	24
Oats	1,911	00
Peas.....	195	30
Spring Rye.....	55	35
Total	4,013	

Total grain yield would have been still larger by at least 200 bushels, as 6.38 acres of peas have been saved for hay.

HAY.

Clover.....	146.8	tons
Pea hay	24 24	"
Total	171.04	tons

STRAW.

Oat	35.9	tons
Wheat.....	14.3	"
Barley	45.9	"
Pea	4.53	"
Rye	1.41	"
Total.....	102.04	tons

POTATOES AND ROOTS.

Potatoes	342 bushels, 42 pounds
Sugar beets.....	20,120 pounds or 10 tons 120 "
Mangles	6,900 " " 3 " 900 "
Rutabagas	5,430 " " 2 " 1,430 "
Carrots	12,170 " " 6 " 170 "
Total	44,720 pounds or 22 tons 620 pounds

The average yield per acre of the various crops are:

Barley.....	27.15	acres, yield, 1,482 bushels, 36 pounds: average, 54.61 bushels
Wheat.....	8.63	" " 380 " 24 " " 44 08 "
Oats	25.71	" " 1,911 " 00 " " 74.32 "
Mummy peas..	2.04	" " 107 " 50 " " 52.90 "
Canadian Golden Vine Peas (part threshed) averaged		37.00 "

HAY.

Clover.....	43.61	acres, yield, 146.8 tons or 3.36 tons per acre
Grain hay.....	6.38	" " 24.24 " " 3.8 " " "

STRAW.

Barley, average yield of straw per acre.....	3,385	pounds
Oats, " " " " "	2,795	"
Wheat, " " " " "	3,315	"
Rye, " " " " "	2,822	"

POTATOES AND ROOTS.

Potatoes.....	1.31 acres, yield, 342 bushels, 45 pounds, average per acre 261.64 bu.
Sugar beets..	1.00 " " 10 tons, 120 " " 10 tons, 120 pounds
Mangels.....	0.11 " " 3 " 900 " " 31 " 162 "
Rutabagas...	0.21 " " 2 " 1,430 " " 12 " 908 "
Carrots.....	0.25 " " 6 " 170 " " 24 " 680 "

The yield and averages given include the total area of farm and trial crops. The clover crop of the past summer was below the average, due to a cold, backward spring. The second cutting gave by far the greater return. A small lot consisting of 4.52 acres produced 14.11 tons at the second cutting. In 1900 a field of 7.26 acres produced 36.45 tons at two cuttings. During the past season one acre of clover sown May 17, irrigated three times and harvested September 7, gave a yield of 3,020 pounds of well cured hay. The large yield from the pea hay was due to a particularly rich, moist soil. The average of the potato crop was probably reduced somewhat by a number of inferior varieties which were included in the tests. The whole area given was irrigated, the barley, wheat and peas were watered once, oats twice, and clover part twice and part three times. We desire to call attention to the fact that the averages were secured from fairly large areas except in the case of the root crops.

This data is furnished for the purpose of giving some idea of the productiveness of a Montana farm under irrigation. In so doing, however, we do not advocate such a wide diversification for the average farmer, as in many instances it would not be practicable. The cost of producing this crop cannot be easily estimated; being a test crop a large amount of additional labor was required in measuring both the areas and the water used in each case, and an endless amount of separate weighing at threshing time.

The value of the crop is here stated:

Barley, 1,482 bushels, 36 pounds, at 85 cents per hundred weight.....	\$ 604.96
Wheat, (Fife) 380 bushels, 24 pounds, at 62 cents per bushel.....	247.26
Oats, 1,911 bushels at 80 cents per hundred weight.....	535.08
Peas, 185 bushels, 30 pounds, at \$1 per bushel.....	185.50
Spring rye, 55 bushels, 35 pounds, at \$1 per hundred weight.....	31.15
Clover hay, 146 8 tons at \$5 per ton.....	734.00
Pea hay, 24.24 tons at \$3.50 per ton.....	84.84
Straw, 102 tons at \$1 per ton.....	102.00
Potatoes, 342 bushels, 45 pounds, at \$1 per hundred weight.....	205.65
Sugar beets, 10 tons, 120 pounds, at \$4.25 per ton.....	42.75
Rutabagas, carrots, mangels, 12 tons, 500 pounds at \$3.50 per ton.....	42.87
Total.....	\$2,816.06

The valuations placed on the above products are the current prices which are being paid for the same on the Bozeman market in the case of the grains, and in the stack in the case of hay and straw. These products will represent a still greater cash value after having been fed to live stock and marketed in the form of meat. Proof of this assertion is based on the fact that during the winter of 1899 and 1900, while clover was being sold in the stack at \$5 per ton, \$7.93 was secured by this Station by feeding clover to sheep. It required 11.8 pounds of clover to maintain a lamb and produce a pound of gain. One ton of clover produced 169.5 pounds of mutton, which at \$4.68 per cwt. gave the above result.

Following up the question of crop production under irrigation in Montana we find it bears an important relation to the live stock industry. In using the crop of 1900, which was mostly consumed on the Station farm, thirty-one steers were fattened for market through a period of 137 days; 289 lambs were also fed throughout 120 days. In addition to this food was supplied for eight work horses, eleven head of dairy stock, from sixty to seventy pigs and an average of 200 chickens. Some grain was disposed of for seed purposes. It has become an annual practice of this Station to feed a carload each of steers and lambs, under experiment, for shipment when finished.

REPORT OF SIX-YEAR ROTATION EXPERIMENT.

F. B. LINFIELD, Agriculturist.

In the fourth and fifth Annual Reports of the Montana Experiment Station an account is given of the reasons leading up to the starting of a six-year rotation experiment. Six acres were set apart, one acre for each crop in the rotation. From the fourth Annual report I quote: "The land received a light top dressing of barnyard manure in 1896 and the bulk of it had produced a crop of hard Fife wheat the same year averaging 20 bushels per acre. It is proposed to shift the crops each year one space so that at the end of the rotation test the same crops will occupy the same position that they did in the beginning of the experiment. No manure or fertilizer will be used during the life of the experiment."

The plat of ground was selected because of its fairly even quality and being fairly representative of the Station farm.

The order of the rotation crops was as follows:—For plat one, wheat, clover, barley, roots, oats and peas. These six crops were grown on all the plats, but the first crop on plat two was clover, on plat three barley and so on for the others. The arrangement of the crops placed a leguminous or nitrogen gathering crop or a hoe crop between each cereal crop. This is an excellent arrangement if it is desired to grow equal areas of as many varieties of crops.

The plats apparently received ordinary farm treatment as regards cultivation and irrigation. For the grain crops the land was ploughed in the autumn; in the spring cultivated twice, levelled and rolled before seeding. No special effort was made to get extraordinary yields.

Spring wheat was grown as the wheat crop throughout the experiment and the common varieties of oats and barley were used. The roots grown were sugar beets and the peas the Canadian field pea. The clover was not sown with the crop of the previous year as is generally the custom, but was sown in the spring. The clover crops reported, therefore, are the crops grown the same season as seeded. The clover sod was plowed up in the fall preparatory to the next year's crop.

The crop of 1902 completes the six years of the experiment as planned and the results are presented in two tables, one arranged by years and the other by plats. In the earlier years of the experiment the grain yields only are given, the yield of straw being neglected. The weight of the straw would have added considerable to the value of the results as then the total crop could have been given. Financially, however, the yields of grain, roots and hay are the important factors and they are given in the table.

This experiment was started to illustrate the advantage of a rotation of crops as contrasted to summer fallowing which was practiced to a large extent even on the irrigated farms of this state. The claims for rotation are that the fertility of the land and thus the yield of the crops could be maintained by this method without the loss of a crop, as is the case with summer fallow. Rotation, it is also claimed, is equally efficacious with summer fallowing in cleaning the land of weeds and in overcoming insect pests.

The farm crops may be divided into two main classes, viz., the cereals and the legumes. The legumes through their root tubercles have the power of gathering the free nitrogen of the air and storing it in the top and root of the plant. Clover, alfalfa, peas and beans are common illustrations of this class of plants. After any of these crops are grown on a soil, although they store very large quantities of nitrogenous compounds in their substance, yet they leave the surface soil richer in nitrogenous plant food than the soil was before the crop was grown.

The other class of plants, the cereals, such as wheat, oats, barley and rye, have not the power of fixing free nitrogen, but must get their nitrogenous compounds in a readily available form. They, therefore, have to feed upon the supply provided by the legumes and left in the soil in the roots of the leguminous crops. These crops are, therefore, in a measure complimentary to each other—the one storing the plant food in the soil that is needed by the other.

Summer fallow adds but little if anything to the soil, but through the cultivation and the season's rest more of the plant food in the soil is rendered soluble and thus is available for future crops. The losses due to leaching of land when summer fallowed in the humid regions would not apply to Montana as here the

rainfall is not sufficient to wash away any of the dissolved plant food. The main objection to summer fallowing and to the continued growing of cereal crops is, first the loss of one season's crop, and second the drain on the soil fertility, particularly on the nitrogenous compounds, which must finally result in soil depletion. That even the very fertile soils of the valleys of the arid region may be exhausted by continued grain growing has been demonstrated in many parts of the state of Utah after 30 to 40 years of farming. Land which at one time yielded 40 to 50 bushels of wheat per acre failed to produce half this return and in some cases one-fourth of this yield, even on irrigated land.

In a rotation experiment not only must the plats be of equal area but the ground must be of as even quality as possible for each plat. It would appear that in this case some of the plats were more fertile than others and this will partly explain some of the variations noted in the returns by year. In examining the table arranged by plats it will be noted that plats five and six gave the largest yield of wheat, plats two and six gave the largest yield of barley, plat three gave the largest yield of clover, plats four and six the largest yield of sugar beets and plats one, four and six the largest yield of oats. In summing up it will be noticed that plat six gave the largest yield for three crops and came near to the top for every crop. Several of the other plats gave much higher yields for some crops than for others. These facts must be remembered in considering the results by years.

Next considering the results by years: The spring wheat gave the largest return in the second year on plat six though the third year was nearly equal to it. The fourth year the yield fell off, but for the fifth and sixth years the crop was practically equal to the crop of the first year.

The clover crop on the whole shows a very uniform yield for all the years. The sixth year gave the largest yield.

Barley gave the largest return in the fourth year on plat six with the second year next. Eighty-seven and a half and 83½ bushels per acre are certainly very good returns. The third and fifth year's crop was over 60 bushels per acre, and the sixth crop was six bushels larger than the first crop.

The crop of sugar beets was larger the first year than for any

year later, viz. $13\frac{1}{2}$ tons per acre. Plat six in the fifth year gave the next largest yield, viz. 10 tons per acre. The sixth year's crop falls nearly five tons behind the first year but it is over $1\frac{1}{2}$ tons larger than the crop of the second year.

The largest yield of oats was in the fifth year with 85 bushels per acre. This crop, however, maintained a high average all through the test after the first year. The crop for the sixth year was 35 bushels larger than for the first year.

In the record book the crop of peas for the first year is as given in the table, 54 bushels per acre. But in the fifth Annual Report of the Station the reported yield is $29\frac{1}{2}$ bushels. Again for the sixth year several hogs had the run of the fields for a month or more while the peas were on the ground, and this undoubtedly reduced the yield as threshed. On another part of the farm the same variety of peas gave a very much larger yield. For these reasons the first and last year's results are not to be relied upon. For the other years the results are fairly uniform:

Considering the results as a whole and allowing for the variations in the fertility of the different plats, I believe the results show that the crop-producing ability of the land has been maintained. The largest average returns from the cereal grains was in the second year. Barley gave the largest yield in the fourth year and oats in the fifth year.

To draw any positive conclusion would not be warranted for two reasons. First, there is evidently a difference in the fertility of the plats, or of their adaptibility to the various crops. In the second place, climatic conditions might have very much influence in increasing or decreasing the yield of certain crops in certain years. It is a well known fact that some seasons are much more favorable to certain crops than are other seasons and thus to draw correct conclusions from the crop yield as to the results of a certain rotation, the general climatic conditions and their general effect upon the crops for any particular season must be known. This record is not available, at least I can find no data on the subject in the records.

To get conclusive results, this test should be continued for another six to twelve years. It is thought, however, that while this

is a good rotation yet it is scarcely practical, and so the matter will be taken up in another form and a direct comparison made with summer fallow.

There are several ways in which the principles involved in this rotation may be realized and yet afford a shorter rotation and more elasticity in the acreage of the various crops grown. A few such rotations are suggested:

- No. 1. Wheat and barley.
Clover.
Roots, oats and peas.

A three year rotation throwing a third of the farm into wheat and barley. Another third into clover, an enriching crop, and another third into roots or potatoes, oats and peas.

Yet another possibility is:

- No. 2. Wheat and barley.
Clover and peas.
Potatoes, roots, oats and barley.

This would give a larger crop of cereals; two fields of barley each year. The clover crop would also be smaller than in No. 1.

Other combinations can be readily worked out, the idea being to rotate the cereal, the enriching, or nitrogen-gathering crop, and the land-cleaning crop. The manure should be applied to the nitrogen-gathering crop as this will increase the vigor of the crop, and enable it to store an increased amount of plant food for the succeeding crops.

TABLE I The yields of the 6 year rotation plats arranged by years.

CROP.	FIRST YEAR.		SECOND YEAR.		THIRD YEAR.		FOURTH YEAR.		FIFTH YEAR.		SIXTH YEAR.	
	Plat No.	Yield.	Plat No.	Yield.	Plat No.	Yield.	Plat No.	Yield.	Plat No.	Yield.	Plat No.	Yield.
Wheat.....	1	43 bus.†	6	53½ bus.	5	52 1-6 bus.	4	38⅓ bus.	3	45 5-6 bus.	2	42¼ bus.
Clover.....	2	1950 lbs.	1	3159 lbs.	6	3090 lbs.	5	3170 lbs.	4	3170 lbs.	3	3500 lbs.
Barley.....	3	48.6 bus.	2	83½ bus.	1	68 bus.	6	87 3-5 bus.	5	61½ bus.	4	54½ bus.
Sugar Beets	4	27280 lbs.	3	12072 lbs.	2	15631 lbs.	1	16310 lbs.	6	20120 lbs.	5	16900 lbs.
Oats.....	5	45 bus.	4	81¼ bus.	3	78 bus.	2	75 3-5 bus.	1	85½ bus.	6	80⅓ bus.
Peas.....	6	54 bus.*	5	23.1 bus.	4	34½ bus.	3	37 bus.	2	37½ bus.	1	12½ bus.‡

*Fifth Annual Report gives 29½ bushels, but record book says 54 bushels.
†Fifth Annual Report gives 40 bushels, 57 pounds, but record book as above.
‡Pigs were running on ground and must have thrashed out some peas.

TABLE II The yields of the 6 year rotation plats arranged by plats.

CROP.	PLAT I.		PLAT II.		PLAT III.		PLAT IV.		PLAT V.		PLAT VI.	
	Year.	Yield.	Year.	Yield.	Year.	Yield.	Year.	Yield.	Year.	Yield.	Year.	Yield.
Wheat.....	1897	43 bus.†	1902	42¼ bus	1901	42 5-6 bus.	1900	38⅓ bus.	1899	52 1-6 bus.	1898	53½ bus.
Clover.....	1898	3159 lbs.	1897	1950 lbs.	1902	3500 lbs.	1901	3170 lbs.	1900	3170 lbs.	1899	3000 lbs.
Barley.....	1899	68 bus.	1898	83½ bus.	1897	48.6 bus.	1902	54½ bus.	1901	61½ bus.	1900	87 3-5 bus.
Sugar Beets	1900	16310 lbs.	1899	15631 lbs.	1898	12072 lbs.	1897	27280 lbs.	1902	16900 lbs.	1901	20120 lbs.
Oats.....	1901	85½ bus.	1900	75 3-5 bus.	1899	78 bus.	1898	81¼ bus	1897	45 bus.	1902	80⅓ bus.
Peas.....	1902	12½ bus.*	1901	37½ bus.	1900	37 bus.	1899	34½ bus.	1898	28.1 bus.	1897	54 bus.‡

*Pigs were running in the field after peas were cut and must have thrashed some.
†Fifth Annual Report says 40 bushels, 57 pounds, but record book as above.
‡Fifth Annual Report gives 29½ bushels, but record book says 54 bushels.

CHEMICAL DEPARTMENT.

F. W. TRAPHAGEN, CHEMIST.

SUGAR BEETS.

The past season has brought a disappointment in the co-operative sugar beet work. From over 500 samples of seed sent out only thirty farmers have returned beets for analysis.

The season has not been as favorable to the growth of good beets as the preceding summer, yet the results are exceedingly gratifying, and give renewed confidence in the belief expressed repeatedly in the past, that "Montana conditions are favorable to the production of sugar beets of high sugar content and standard purity."

The richest lot of sugar beets so far produced in Montana was grown this year. These beets contained 22.8 per cent. sugar, and were grown in Valley County, by W. M. Wooldridge, of Hinsdale.

Because of misplacement of notes on the variety tests of beets, incident to Prof. Shaw's departure, all of this work is lost for the present year. This is particularly unfortunate for the analysis has shown a marked difference in composition in the different varieties.

ANALYSES OF GRASSES.

Appended is a series of analyses of grasses, both on the air dried and water free basis, These grasses were collected by Mr. Spragg and are described in bulletin No. 36. The analyses show that grasses of the same species, gathered at different periods at different stages of growth, may differ in composition to a greater degree than grasses of totally different genera, collected under similar conditions.

DESIRABILITY OF DIGESTION EXPERIMENTS.

Definite knowledge of the composition and digestibility of Montana forage plants is very desirable, but until facilities are provided at the Experiment Station for carrying on this highly important work, we will be compelled to do without this information. It is very generally believed that our range grasses are unusually nutritious, but aside from noting the growth of cattle feeding on these grasses, nothing has been done to secure definite information.

These observations have, of necessity, been too general in their character to be of much use. The only way to get this information is by conducting careful feeding tests under conditions absolutely under control, in which the digestibility of each of the important grasses with cattle, swine, sheep and horses shall be determined. It is hoped that the legislature will make such work possible by providing suitable quarters, materials and apparatus for carrying on the work.

FLAX.

Mr. Daniel Payne, of Monarch, Mont., supplied me with a sample of flax grown in 1901, which yielded the following analysis:

Moisture	3.72 per cent.
Crude Protein	22.10 " "
Ether Extract (Oil)	39.18 " "
Nitrogen, Free Extract	28.58 " "
Crude Fibre	5.20 " "
Ash	3.22 " "

The very high grade of this sample will be appreciated when noted in comparison with the product of other countries.

Flanders	39 per cent.
Russia	35 " "
Nantes	33 " "
Brittany	31 " "
Hamburg	30 " "
St. Petersburg	29 " "
Montana	39.2 " "

The results show that Montana may be expected to yield crops of flax seed containing an unsurpassed quantity of oil, and would indicate another crop which might profitably be added to those already successfully cultivated.

The oil cake left after extracting the oil is a very rich cattle food and would serve a very useful purpose in finishing stock for the market.

HARDENING OF SOFT WHEAT.

The following remarkable change in composition and characteristics was found in the case of wheat grown from soft wheat seed without irrigation:

	Moisture	Crude Protein	Ether Extract	N-Free Extract	Crude Fibre	Ash
Soft wheat seed	7.87	8.81	1.93	76.99	2.60	1.80
Hard wheat from above ...	7.65	14.44	2.23	71.33	2.65	1.70

The samples from which the above results were obtained were furnished by Mr. Daniel Payne of Monarch.

SOFTENING OF HARD WHEAT.

The question of the change of the protein content of grains under irrigation is receiving considerable attention in our laboratory, and we hope to furnish soon some figures to illustrate fully these changes.

The purpose of this work is to learn how to control the percentage of protein and also to increase it when it is desired.

GRASSES FROM ALKALI DISTRICTS.

Mr. I. D. O'Donnell of Billings furnished five samples of grass, the composition of which is given in the table following:

AIR-DRY BASIS.	Lab. No.	Mois- ture.	Crude Protein	Ether Extr.	N-free Extr.	Crude Fibre.	Ash.
Agropyron spicatum S & S "Blue Stem"	2010	5.35	7.00	4.00	40.52	34.80	8.33
Poa arida, Vasey.....	2012	4.52	5.75	3.25	44.08	37.70	4.70
Poa flava, L. "Red Top".....	2009	5.62	7.94	4.10	39.24	33.90	9.20
Stipa comata, Trin. & Rufr.....	2013	5.36	5.75	3.33	55.39	26.05	4.12
Stipa viridula, Trin.....	2011	5.00	8.40	3.50	41.11	36.20	5.79
WATER-FREE BASIS.							
Agropyron spicatum S & S "Blue Stem"	2010	....	7.39	4.22	42.81	36.77	8.80
Poa arida, Vasey.....	2012	....	6.02	3.40	46.17	39.48	4.92
Poa flava, L. "Red Top".....	2009	....	8.41	4.34	41.58	35.92	9.74
Stipa comata, Trin. & Rufr.....	2013	....	6.07	3.51	58.52	27.52	4.35
Stipa viridula, Trin.....	2011	....	8.84	3.68	43.27	38.10	6.09

REMARKS.

- 2009—Cut green, grows in damp alkali places.
- 2010 Hesper farm, rank growth, cut late, seeded out, yield about 2 tons.
- 2011—A new grass to neighborhood. Found in strongest alkali places where only foxtail and this grass grow.
- 2012 Grows along ditches on Hesper farm.
- 2013 Makes good hay when cut green.

WHEAT ANALYSIS.

A wheat locally known as "Lemon Rye" and as "Wild Goose wheat," grown by J. W. Kelley, Lewistown, gave the following analysis:

Lab. No.	Moisture	Crude Protein	Ether Extract	N-free Extract	Crude Fibre	Ash
2061	8.17	14.56	1.53	71.44	2.24	2.06

Concerning this wheat Mr. Carleton, cerealist of the United States Department of Agriculture, has this to say:

"The wheat is correctly called Polish wheat, belonging to the sub-species *Triticum polonicum*. Wild goose wheat is a very different sort, belonging to the durum or macaroni wheat group. Polish wheat, however, is also used for making macaroni and is very hard grained, which is probably the reason why it has been confused with the varieties of macaroni wheat. The sample you enclose is an unusually good specimen of this wheat, the grains having the full length and size otherwise. A number of samples that I have received from other parts of the country have been rather inferior."

CONSERVATION OF SOIL FERTILITY.

When attention has been called to the wasteful methods followed by most of our farmers throughout the state, the methods which take plant food from the soil without returning anything, the rejoinder has usually been, "Oh well! the water we use in irrigation more than makes up for the losses by removal of crops."

An inspection of the facts will show that this is far from being true. On the basis of a yield of only fourteen bushels of wheat per acre, and the average for the United States is slightly less than that amount, and assuming two pounds of straw for each pound of grain, the amount of plant food removed from each acre is as follows:

Nitrogen	29.73 pounds
Phosphoric acid	9.49 "
Potash	13.69 "

The lowest price attached to these foods in commercial mixed fertilizers, which will have to be resorted to ultimately if present methods are continued, is for ammonia fifteen cents a pound, for phosphoric acid four and a half cents a pound and for potash five and a half cents a pound.

Applying these prices to the quantities removed by the wheat crops cited above gives the following results:

Ammonia (17-14 nitrogen) 29.73 pounds at 15 cents.....	\$5.41
Phosphoric acid, 9.45 pounds at 4.5 cents.....	.42
Potash, 13.69 pounds at 5.5 cents.....	.75
	<hr/>
	\$6.58

As a matter of fact in Montana where thirty or forty bushels are not uncommon yields, as a consequence the drafts on the soil are far greater than in the case of the smaller yields. Thus from thirteen to eighteen dollars or even more may be removed by a single wheat crop from each acre.

Now let us see what we have to compensate us for such losses. Appended is the result of analysis of a series of waters which are typical of Montana irrigating waters. The results are expressed in parts per million and can be converted approximately into pounds per acre-foot by multiplying by two and three-quarters which is about the number of millions in weight of an acre-foot. Multiplying this product in turn by the price per pound of the plant food as previously given we get the value of the plant food contributed by the irrigation water.

This amount is pitifully small when considered as a means of supplying the food annually required by the crop.

IRRIGATING WATER.—Results expressed in parts per 1,000,000.

Lab. No.	DESCRIPTION.	Total Solids.	Organic Matter.	Silica.	Ferric Oxide and Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Potash.	Soda.	Sulphuric Acid.	Nitrogen.
783	Middle Creek...	77.0	24.0	15.8	0.9	22.6	6.1	0.41	0.8	3.7	0.34	trace
788	Yellowstone Riv.	96.0	32.0	11.2	1.1	21.0	8.3	0.41	1.9	22.1	17.0	"
789	Missouri River..	221.0	64.0	18.9	3.1	52.8	18.1	0.22	1.9	30.0	21.9	"
790	Shields River...	186.0	34.0	6.8	1.3	74.5	15.0	0.35	0.14	18.0	20.0	"
791	Bozeman Creek.	117.0	31.0	20.2	1.5	32.2	12.8	0.44	0.9	6.3	3.4	"

An inspection of the table shows the phosphoric acid to range in quantity from forty-four hundredths down to twenty-two hundredths parts per million. The larger amount would be equivalent to about five cents worth of phosphoric acid per acre-foot of water applied, while the maximum quantity of potash was one and nine-tenths parts per million, equalling five pounds per acre foot, and worth twenty-eight cents.

The nitrogen is found only in minute quantities, amounting to only a few parts in one hundred million, an amount so inconsiderable as to be of little value, and some is supplied in rains and snows. Add to this the fact that the nitrogenous plant foods are those most easily lost by careless methods of culture, and note that this most expensive plant food is the one most extensively removed by the crops under consideration, and the importance of immediate attention to this point will at once become apparent.

Two methods of meeting the issue are proposed, these are tried and proved and will not be experiments. First restore the nitrogen of the soil by a system of rotation introducing leguminous plants, preceded if necessary, by the application of nitrate, and second, feed as much of the produce of the farm as is practicable, marketing your produce "on the hoof" as far as you find it possible to do so.

If this practice shall be adopted before it becomes too late Montana will be a state where the "worn out abandoned farm" is unknown.

Up to the present time commercial fertilizers so common in other states have found no sale in Montana. But now manufacturers are turning their attention to us as probable customers, and already numerous enquiries are being received by the Station concerning laws, markets and conditions. The amount of commercial fertilizers that will be sold in Montana in the future depends very largely upon how well the farmer regards the frequent warnings given him, and how successfully he applies the remedies proposed.

It is not too soon to pay close attention to the use of farmyard manures and to the sheep manure so plentiful in many parts of the state.

STOCK WATERS.

In many portions of the state are alkali pools and alkali springs. As water is scarce the question of the suitability of these waters for use by stock becomes a very important matter. Through the courtesy of Mr. I. D. O'Donnell, of Billings, I have secured samples of water typical of the alkali districts. A table, giving in part, the composition of these waters is added for inspection. Most of these waters are very largely used for watering sheep and cattle and, except in the instances mentioned, appear to be well adapted to this purpose, the relatively large proportion of salts appearing to produce no bad results.

ALKALI WATERS.- Parts per Million.

		Chlo- rine.	Com- mon Salt.	Sulph- uric Acid.	Glau- ber's Salt.
998	Custer Cattle Co., main watering place...	752.4	1239.87	1433.44	5769.59
1007	I. D. O'Donnell, 10 acre farm Billings...	1416.8	2334.72	5399.7	21733.79
1985	Ed. Cardwell, four miles west of Billings.	424.0	698.7	2933.0	11805.3

Notable exceptions, however, are numbers 1,007, which is positively refused by stock, and 1,985. The latter water is certainly the cause of the death of a considerable number of head of cattle, particularly of young stock.

Mr. Cardwell kindly furnished us with a considerable quantity of this water, which comes from a well on a farm which is used for winter feeding stock. This water is pumped into troughs by a windmill from a depth of about 40 feet.

Mr. Chesnut conducted some experiments to determine the effect of this water on sheep, and although as much as two and a half quarts were administered at a time to an adult ewe, no physiological effect was produced. It is probable that the ill effects from the use of this water are only experienced by young, weak or tired animals.

There are few waters in the state more highly charged with mineral salts than the samples in the table, and it may be taken as almost an axiom that whatever water is drunk by stock on the range is a fairly safe water.

PUBLICATIONS.

Since the issue of the last annual report a bulletin on sugar beets has been published from this department, one on food adulteration is in the press and two more, one on sugar beets, and one on flax in Montana, are in preparation.

MISCELLANEOUS.

Other matters receiving attention are on the effects of tailings and tailings waters on vegetation, adaptation of crops to certain soils, liming or other treatment, the changes undergone by grains under irrigation and studies of soils, etc.

The routine work of the department has grown far beyond the capacity of the present laboratory staff consisting of Mr. Burke and myself, who have only part of our time to devote to the laboratory work, much time being given to administration, teaching and Farmers Institute work. My own time could most profitably be occupied in matters of administration and research, but under existing conditions, much of it must be given to purely routine work, which a low salaried assistant could perform very satisfactorily under my supervision. It is extremely doubtful if there is another Experiment Station in the country with as small a laboratory corps.

I would most respectfully urge the appointment of an assistant for my department as soon as funds can be found for the purpose.

WATER-FREE BASIS.

DESCRIPTION.	Date Collected.	Lab's No.	Nitrogen.	Crude Protein	Ether Extract	N-free Extract.	Crude Fibre.	Ash.
<i>Agropyron occidentale</i> , Scribn. Face of Arrow Creek hill 3 miles below Benton	7-3-01	2020	87	3.11	3.96	42.61	37.60	9.76
	8-14-01	2030	88	5.77	2.08	51.49	35.76	4.84
	7-16-01	2022	94	3.87	2.88	50.64	31.63	8.99
	7-12-01	2021	143	8.93	1.86	41.33	30.41	8.47
	7-19-01	2026	73	4.59	2.17	54.04	29.16	10.03
	7-5-00	2024	125	8.03	1.57	46.71	32.53	11.12
	7-16-01	2024	194	12.13	3.08	42.30	30.26	11.01
	8-3-01	2030	121	7.59	2.37	54.36	28.41	7.05
	7-1-01	2015	168	10.49	3.21	43.47	32.77	4.02
	8-2-01	2017	161	10.06	2.88	58.18	18.65	10.13
	7-11-01	2040	133	8.95	2.23	41.18	37.37	10.76
	7-1-01	2047	15	6.81	1.86	46.25	36.42	8.65
	8-8-01	2039	80	5.63	2.93	50.59	34.03	6.03
	7-17-01	2038	73	4.71	2.07	47.61	39.13	6.47
	7-13-01	2011	82	3.11	2.04	49.65	35.09	8.09
	7-12-01	2036	127	7.93	2.09	45.74	35.50	8.89
	7-6-01	2030	90	3.63	2.61	51.10	27.60	12.25
	7-17-01	2014	122	7.62	4.33	41.18	33.88	10.76
	7-12-01	2041	144	9.02	2.04	40.07	36.63	12.44
	7-1-01	2036	102	6.36	3.08	48.27	37.34	4.93
	8-16-01	2031	122	7.62	2.79	43.62	35.35	0.61
	7-10-01	2023	110	6.90	2.45	51.90	30.37	8.17
	8-5-01	2038	122	7.67	3.57	46.70	31.03	10.03
	6-17-00	2012	128	8.02	2.63	45.13	31.42	12.77
	6-29-01	2044	81	3.49	3.65	51.01	30.31	9.73
	7-30-01	2042	108	6.77	1.15	45.25	35.24	10.57
	8-1-01	2029	114	7.14	2.92	48.10	31.00	10.22
	6-21-00	2033	153	9.61	2.67	49.19	30.94	7.59
	7-17-01	2018	87	5.48	2.68	52.62	31.79	7.39
	7-16-01	2043	87	5.73	2.17	42.93	38.27	10.90
	7-17-01	2046	104	6.53	2.75	49.85	31.01	9.86
	8-20-01	2017	80	5.01	2.43	58.92	28.53	5.07
	8-7-01	2045	111	6.95	3.28	47.19	32.98	9.74
	7-3-01	2049	49	4.29	3.11	52.50	33.49	6.59
	6-29-01	2025	103	6.42	2.50	48.57	34.45	8.04
	8-13-01	2050	84	5.25	2.57	54.80	29.70	7.67
	7-2-01	2018	94	5.65	1.81	28.18	53.34	7.44
	7-2-01	2019	122	7.68	3.33	46.25	34.16	8.38
	7-27-01	2028	123	7.09	3.45	52.54	29.19	8.10
	7-12-01	2037	113	7.07	2.22	44.87	37.13	8.71
	7-16-01	2023	99	6.16	3.38	52.05	38.60	10.80
	7-23-01	2027	149	9.34	2.87	50.38	28.37	9.52
<i>Spartium cynosuroides</i> , (L.) Willd. Wet meadows near Denton								
<i>Sporobolus brevifolius</i> , Scribn. Wet meadows near Denton.								
<i>Sporobolus cryptandrus</i> , (Torr.) Gray. Sandy hills near mouth of Pine Coulee								
<i>Stipa comata</i> , T. & G. Needle grass, Lake basin south of Benton								
<i>Stipa spartea</i> , Trin. Dry hill tops west of Square Butte								
<i>Stipa viridula</i> , Vasey. At mouth of Pine Coulee.								

AIR-DRY BASIS.

DESCRIPTION.	Date Collected.	Lab's No.	Moisture.	Nitrogen.	Crude Protein.	Ether Extract.	N-free Extract.	Crude Fibre.	Ash.
<i>Arundo donax</i> occidentalis. Scribn. Face of Arrow Creek hill 3 miles below Benton.	7-3-01	2020	4.07	.83	5.19	3.10	40.88	86.70	9.36
	8-14-01	2060	4.40	.84	5.50	3.18	49.02	34.05	4.65
	7-16-01	2022	4.05	.83	5.63	3.18	48.58	30.25	8.63
	7-12-01	2021	3.32	.85	8.63	3.80	89.06	38.10	8.19
	7-19-01	2026	3.30	.71	4.44	2.10	52.26	26.20	9.70
	7-5-00	2034	4.55	1.23	7.66	1.50	44.59	31.03	10.62
	7-16-01	2024	3.34	1.88	11.75	2.98	41.17	29.25	11.31
	8-8-01	2020	2.40	1.18	7.36	2.50	52.80	27.60	6.86
	7-1-01	2013	3.35	1.62	10.13	3.10	43.85	31.60	7.75
	3-2-01	2017	3.06	1.56	9.75	2.90	36.48	18.10	9.83
	7-11-01	2040	4.87	1.27	7.94	2.22	39.18	35.55	10.24
	7-1-01	2017	4.60	1.10	6.50	2.40	44.12	34.75	8.26
	8-8-01	2036	4.70	.77	4.81	2.80	48.22	32.45	6.32
	7-17-01	2038	4.13	.72	4.50	1.98	45.50	37.40	6.19
	7-13-01	2031	4.55	.78	4.88	1.95	47.80	33.50	7.73
	7-12-01	2036	4.08	1.22	7.63	2.00	43.08	34.10	8.51
	7-6-01	2030	4.45	.96	5.36	2.30	49.59	26.37	11.74
	7-17-01	2014	4.13	1.17	7.31	4.37	39.48	32.40	10.31
	7-12-01	2041	4.32	1.38	8.63	1.95	38.34	35.05	11.71
	7-1-01	2016	2.80	.99	6.19	3.00	46.92	36.30	4.79
upon Creek hill. rel.	8-16-01	2081	2.36	1.19	7.44	2.73	42.59	35.50	9.35
	7-10-01	2035	4.00	1.06	6.63	2.35	48.82	29.35	7.85
	8-5-01	2058	4.70	1.17	6.31	3.40	44.51	30.37	10.51
	6-17-00	2032	2.62	1.25	7.31	2.36	48.97	30.60	12.44
Denton k bottom	6-28-01	2044	4.13	.78	4.88	3.50	48.91	33.80	9.23
	7-30-01	2042	4.11	1.04	6.50	2.06	43.99	30.70	9.93
	7-1-01	2029	2.87	1.11	6.94	2.84	46.98	29.55	7.25
	6-21-00	2033	4.48	1.47	9.18	2.53	46.98	29.55	7.25
xx Mt., Alt. 7500 ft. rise Creek	7-17-01	2048	3.83	.84	5.50	2.54	49.84	30.10	7.00
	7-16-01	2043	4.11	.84	5.50	2.08	41.10	26.70	10.51
	7-17-01	2046	5.19	.99	6.19	2.61	47.26	29.40	9.85
	8-20-01	2037	5.30	.78	4.75	2.30	55.83	27.02	4.80
of Pine Coulee	8-7-01	2015	5.38	1.05	6.56	3.10	44.56	31.00	9.20
	7-5-11	2019	5.50	.65	4.06	2.94	49.62	31.65	6.23
	6-29-01	2025	3.65	.98	6.19	2.41	46.90	33.20	7.75
	6-13-01	2059	4.83	.80	5.00	2.45	52.15	25.27	7.90
of Pine Coulee on	7-2-01	2013	2.71	.88	5.50	1.70	24.74	57.70	7.23
	7-2-01	2019	3.11	1.19	7.44	3.23	44.81	36.10	8.31
	7-27-01	2028	3.23	1.19	7.44	2.40	50.48	28.25	7.84
	7-12-01	2037	4.54	1.08	6.75	2.12	42.93	35.45	8.31
<i>Stipa spartea</i> , Trin. Dry hill tops west of Square Butte <i>Stipa viridula</i> , Vasey. At mouth of Pine Coulee	7-16-01	2023	3.40	.95	5.94	3.25	49.97	27.55	9.89
	7-23-01	2027	3.06	1.45	9.06	3.30	48.83	27.50	9.23

BOTANICAL DEPARTMENT.

J. W. BLANKINSHIP, Botanist.

The work of this department during the eighteen months covered by this report has been devoted mainly to a study of the poisonous plants of the state, their distribution and periods and conditions under which most poisonous, in regard to which a preliminary report has been published in the Proceedings of the Fifth Annual Session of the Pacific Northwest Wool Growers' Association (pp. 49-54) and in various newspapers of the state. During the present season this work has been confined mainly to the loco plant and some very interesting data have been obtained. A large part of the state has been covered and the observations extended to the stock on the ranges, while much valuable information has been secured from stockmen and others in the states adjoining, so that the bulletin on the subject soon to be issued will be more comprehensive than if confined to the conditions of this state alone. Sets of the poisonous plants have been placed in ten of the chief stock-growing centers and these with our descriptive bulletins will give the stockmen and herders sufficient information to enable them to avoid the poisonous localities during the danger season.

Much work has also been done during the year in the study of the forest conditions of the state, in the determination of species and their distribution, as the most efficient means for recognizing the different biological and agricultural zones of the state. In this work a number of the mountain ranges grazed by sheep dur-

ing the summer have been examined and at no point have any evidences been found of injury to the forest growth by such pasturage, as they are herded exclusively upon the mountain meadows.

Six Farmers' Institutes were attended during the year and a paper was published in their First Annual Report on "Shade Trees and Ornamental Vines suitable for planting in Montana," a subject in regard to which a number of inquiries have been made.

During the time covered by this report the botanist has traveled 8,267 miles by rail and 1,046 by other conveyance in connection with his field work and other duties of his office and he has endeavored to familiarize himself with the actual agricultural conditions existing in the different parts of the state. The correspondence of the department is rapidly increasing and in fact is more than five times as much as during the same period immediately preceding. The table below will show the general nature of this correspondence and the principal inquiries made at this office:

	RECEIVED.	SENT.
Poisonous plants.....	95	102
Publications and Bulletins.....	54	66
Apparatus and Supplies.....	39	29
Determination of Species.....	34	34
Collections and Exchanges... ..	30	25
Books for Library.....	21	15
Forage Plants.....	13	15
Weeds	12	13
Official Communications.....	12	14
Shade Trees and Ornamental Vines.....	10	10
Cultivated Plants.....	5	9
Questions of Native Flora.....	10	10
Press Communications.....	..	9
Native Hedges.....	6	6
Fungi and Plant Diseases.....	5	6
Forestry	2	2
Miscellaneous, unclassified.....	24	25
Total.....	372	390

This correspondence is little indication of the work done, for in the matter of the determination of species alone, more than 800 plants have been sent in during this time for determination and additions are being made to our herbarium at

the rate of about 1,800 a year. This entails an enormous amount of work of a character which in large part can not be relegated to student labor. Yet through this means and the regular field work of the department a strong herbarium is being built up of these scientific collections, which must be invaluable in the study of the natural history of the state and very necessary to the economic work of this department.

NOTES ON WEEDS.

During the year my attention has been called to several special troubles in this line.

The alfalfa dodder (*Cuscuta epithymum*, Murr. and *C. arvensis*, Beyr.) has been reported troublesome in two localities in the alfalfa belt. This is a queer, yellow, wax-like parasite sometimes called "love vines," which fastens itself to the alfalfa and saps its strength and has been known to practically exterminate whole fields of this plant. It is much worse in Utah and southward than here, where the climate appears to restrict its spread, but it is a most dangerous introduction and it has not yet been demonstrated that it is not adapted to the conditions prevailing in the Yellowstone valley, so it should be exterminated on appearance without the risk of experiment. Two localities where it has been reported are in the vicinity of Clyde Park in the Shields River region and Big Elk on the Musselshell, where it has been introduced from Utah seeds and has caused considerable trouble. It has appeared in the Madison valley and at several other places in the state, but has died out for some reason without doing any particular damage. It can be exterminated by mowing closely the infested spots and burning them over when dry. More detailed information can be secured in regard to this pest by sending to the Division of Botany, Washington, D. C., for their "Circular No. 14," (free).

A native *Coreopsis* (*C. tinctoria*, Nutt.) appears to be in the way of becoming a nuisance in the Milk River region, where it has spread from its native habitat in ditches and wet places into fields and low land meadows, where it is crowding out the blue-joint and

timothy and its tough stems clog up the mowers so that it is difficult to care for the hay. The large yellow-rayed flowers make it very ornamental and it is frequently found in cultivation, where the rays often become parti-colored with purple. The plant is an annual with finely divided leaves and spreading, branched stem about two feet high. The seeds are carried by water mainly, and it appears to be able to stand anything short of black alkali, so that if it should prove of any value as a forage plant, it might be utilized in alkali places, where most other plants are killed. It appears to be common in the Milk River region from Malta westward to Cut Bank and is one of the prominent flowers in ditches along the railways; it also has spread southward nearly to Great Falls and occurs at Thompson Falls in the extreme western part of the state, though here probably escaped from cultivation. It is locally abundant in this northern section of the state, but of doubtful occurrence elsewhere within our limits. Coming up from the seed, as it does, each year, it ought not to be difficult to exterminate it in pastures and meadows by cutting it before it matures its seed, while its short root and conspicuous yellow flowers would enable it to be found and hand-pulled without difficulty.

It is necessary to warn the people of the state against allowing the Eastern Dandelion (*Taraxacum officinale*, Weber) to secure a foothold in lawns and meadows, as in most places it is a most pernicious weed and difficult to eradicate. It fairly takes the meadows in parts of the Beaverhead and Big Hole valleys and there seems to be no way to stop it short of plowing up these meadows infested with it and sowing them in grain for a few years till it is killed out by cultivation. A weed law is badly needed that will allow communities to co-operate and exterminate these pests systematically at public expense, and if such a law is not soon made our yards, farms and ranches will become as badly infested as those of the Eastern states.

RANGE IMPROVEMENT.

Already the ranges in most parts of the plains region of Montana begin to show the evil effects of overstocking and in many localities are practically exhausted. This is particularly true of the main lines of travel pursued by the different bands of sheep and

in the vicinity of shipping points and shearing corrals, while in many fenced inclosures and even on the open range the grass is becoming more and more sparse, so that only long rest or replanting can ever make them capable of supporting the herds and flocks, which they formerly nourished. While these ranges were public lands no one cared to make improvements, which he must share with the general public or of which he might legally be dispossessed at any time, but within the last few years the stockmen in nearly every part of the state have begun the more practical policy of purchasing outright their holdings and fencing them for private use and but for the policy of the government in holding the public lands for actual cultivation, the arid range would soon be under fence as private ranches.

Nevertheless, much of it is now so held and the question of the improvement of these fenced ranges so as to make them capable of supporting as large a number of animals as possible to a given acreage is becoming of more and more importance and there is a constantly increasing demand for methods of restoring these worn-out ranges and making them more productive, so that during the field-work of the summer this matter has been constantly kept in view, and effort has been made to ascertain by observation and inquiry what species can best withstand this close grazing and are most nutritious and palatable for stock, as well as the general effects produced by over-pasturage.

The effect of close grazing varies with the species, some grasses being quickly exterminated, others persisting in a scattered or weakened condition, while still others not only persist under these untoward conditions, but actually are caused to stool out and spread by such grazing and their seeds are scattered in the offal.

What are these latter species and how can they be established in localities where they are most needed? There are at least three species that seem to fulfill these conditions in a greater or less degree, and I think most of the stockmen will agree with these conclusions.

The "Blue-joint" (*Agropyron spicatum*, Pursh and related species) is one of these and its value for hay and for grazing is too well known to need mention. This is found throughout most of the plains region and occurs in low ground mainly, where there is

not too much alkali, and forms the best native hay lands of this region. Where it is too wet it is drowned out and replaced by wire grass, rushes and sedges; in the drier situations its place is taken by other dry land species. This makes the best hay on the market and the only thing that prevents it from becoming a leading grass in cultivation is its relatively thin distribution and consequently small yield. It spreads freely by underground shoots and can stand a good amount of pasturage, but a variety has not yet been found that will afford a growth sufficient to compete with timothy, alfalfa or clover. Its chief economic use is to afford a wild hay on uncultivated ground, where irrigation is not possible. It is probable that by experimental cultivation we may find a variety or secure one by selection that will become one of the important hay crops for the arid regions.

The second is the "Grama" or "Buffalo Grass" (*Bouteloua oligostachya*, Torr). This species also extends throughout all the interior plains of the United States and into Canada and Mexico, but seems not to be found west of the Rockies or eastward beyond the semi-arid plains bordering the prairie belt, extending from Minnesota to Texas. In Montana it is confined strictly to the plains in the eastern part of the state and its general abundance in the southeast and relative rarity toward the north and west of this region would seem to indicate a southeastern origin and a relatively recent introduction, probably by the agency of the buffalo, as it spreads very slowly and has not yet occupied many lands of the state to which it is perfectly adapted. It seems to be steadily displacing the other grasses on the benches and uplands wherever the ranges are closely grazed and where it has secured an introduction. It spreads in every direction from a central tuft by creeping root stocks, rooting as it goes, and thus forms a deep turf crowned with short, close-set leaves from which the fruiting stems rise, so that close-grazing in no wise injures the steady spread of the plant or its healthy growth, indeed, it even appears to stool the more, when the leaves and fruiting stems are thus cropped. This "grama grass" has long been known for its curing and fattening qualities and it will support more stock to the acre than any other native species, while it is perfectly hardy in the driest situations and does fairly well in the lower valleys where the soil

is not too moist. This and the blue-joint aptly supplement each other, the latter doing well only in the moister situations. This buffalo grass is the grass for planting on the exhausted ranges, as there is no other, native or introduced, that can approach it in the all-round qualities needed for withstanding close-grazing and arid situations and yet afford the best curing and fattening qualities.

There is a third grass worthy of mention, because its value has been long and well tested in the plains of Nebraska, Kansas and Texas, and because its habits approach closely those of the preceding species with which it has been often confused. This is the true "Buffalo grass" or the "Little Buffalo grass," (*Bulbilis dactyloides*, Raf.) as it is sometimes called to distinguish it from the preceding species. This is now spreading into the state from the southeast and has extended up the Yellowstone as far as Forsyth, though it is relatively yet rare. This is smaller and even closer set than the grama grass and its fruiting stalks are not half as high. It spreads in the same way by "runners" lying close to the ground and rooting at the joints, but these runners are much longer than in the preceding species and consequently its spread should be much faster.

These three grasses seem to offer a solution for the exhausted ranges of the state, for the last two at least cannot be killed by ordinary pasturage and furnish far more and better forage than the common range grasses. The problem seems to be how to secure the seed and when and how best to plant them on the ranges. At present no seed house appears to have these seeds in stock and the Station is unable to supply them and until regular plantings are made and these species put upon the market, we shall have to wait and conduct the experimental work at the Station here. Nevertheless, it is possible for the stockmen to purchase hay made up mainly of these grasses and by feeding it on the ranges where it is desired to plant the buffalo grass or the blue joint, it can be thus slowly established.

It is not intended to say that these are all the grasses adapted to our needs here, for there are doubtless others more or less suited to our climatic conditions, but the value of these three species has long been recognized and they seem to possess all the characteris-

tics desired of grasses suitable for planting on these worn-out ranges. Experiments are being conducted at this Station and, if other species are found to meet our needs, the matter will be called to the attention of the stockmen.

SHADE TREES AND ORNAMENTAL VINES IN MONTANA.

As the result of observations in the different parts of the state and of the work at the Station, it is now possible to determine with fair certainty many of the shade trees and ornamental vines adapted to the climatic conditions of Montana. These results have been published in the First Farmers' Institute Annual (pp. 202-210), but a brief summation will here be given for the benefit of those who have not access to that report.

For general agricultural and horticultural purposes the state of Montana may be divided into four general divisions determined by climate:

1. The EASTERN PLAINS, comprising mainly the valleys of the Missouri and Yellowstone below the mountains with their immediate tributaries, the conditions of the higher benches and uplands being more nearly that of the next.

The most reliable and most satisfactory shade tree here is the common cottonwood (*Populus deltoides*) of the bottoms and its near but more graceful relative the Carolina Poplar. The Lombardy poplar (*P. dilatata*) should do fairly well in this region, although it does not appear to have been planted to any extent, and its tall spire-shaped habit would make in very effective in beautifying the landscape in the wider parts of these valleys. The silver poplar also flourishes here, but as elsewhere sprouts badly. Russian poplars have been found hardy and the European willow (*Salix fragilis* or *S. alba*) are perfectly adapted to this region and the latter lends a pleasing variety to the wide leaved trees usually planted, while the weeping willow (*S. Babylonica*) is still more ornamental and can be grown here wherever there is sufficient water for irrigation.

The green ash (*Fraxinus viridis*) is a native throughout most

of this region, but is not as good a shade tree as the white ash (*F. Americana*), which has already been planted to some extent and seems fairly well adapted to the climate at the lower elevations.

The linden or linn (*Tilia Europæa* and *T. Americana*) grow well here wherever they have been planted and the various maples will also be found hardy, probably as far up as Great Falls and Billings, while the box-elder (*Negundo aceroides*) is everywhere planted. Three of the oaks have also been found hardy here, the red (*Quercus rubra*), the white (*Q. alba*) and the bur-oak (*Q. macrocarpa*). It is also probable that the various birches and the mountain ash (*Pirus sambucifolia* and *P. Aucuparia*) can be made grow without difficulty, although they are better adapted to the other regions of the state. The evergreens are unlikely to do well here without careful attention, although the red cedar (*Juniperus scopulorum*), the scrub pine (*Pinus scopulorum*) and the white pine (*P. fragilis*), occurring native over part of this region, are the most promising. The small trailing juniper (*J. Sabina procumbens*) has also been successfully transplanted and makes a beautiful ornament for the yard.

This section is particularly adapted to the various ornamental vines for covering porches, houses, etc. The hop is everywhere planted, as is the wild cucumber (*Echinocystis lobata*), while the Virginia creeper (*Ampelopsis quinquefolia*), the wild clematis (*Clematis ligusticifolia*), the Canary bird flower (*Tropæolum peregrinum*), the morning glory and the sweet pea are frequently found. The beautiful large-flowered species of imported clematis seem also to grow without special protection, while nearly all the eastern annual vines and flowers will do well in these lower valleys wherever sufficient water for lawn irrigation can be secured.

2. MOUNTAIN VALLEYS (east of the Divide, mainly), including the Gallatin, Madison, Jefferson, Beaverhead, Upper Missouri, Deer Lodge and others between 3,000 and 5,000 feet elevation.

The usual shade trees here are the Balm of Gilead, the lance-leaved and the narrow-leaved cottonwoods—all native, as is also the quaking-aspen, frequently found. The river cottonwood and the Carolina poplar are grown under favorable conditions, but are not well adapted to this altitude. The maples all winter-kill, except the native shrub maple (*Acer glabrum*) of the mountains and the oaks

and the elm are unsuited to the climate, although the latter and the bur-oak are growing in sheltered locations at Bozeman. The box-elder does well at Helena, but is clearly not adapted to most of these valleys, and the same may be said of the linden and the two species of ash, although the green ash can be made grow in many places. All the birches and the mountain ash are here in their prime and nearly all the species of evergreen flourish. The silver poplar and the European willows will grow under ordinary conditions, although the first has been found rather tender and the weeping willow is yet doubtful. The Lombardy poplar winter-kills here badly and the dead central trunks become unsightly, but the Russian poplars seem perfectly hardy.

All the vines first mentioned as adapted to the plains region also do well in these valleys, but the season is too short for many of the annuals, like the flowering clematis and the morning glory, as they are apt to be killed by early frosts before they have attained their perfection.

3. The WESTERN VALLEYS, including the Flathead, the Bitter Root, Clark's Fork and the Kootenai, where the rainfall is greater and the temperature more uniform, avoiding the extremes of heat and cold found east of the Divide. This is pre-eminently the horticultural section of the state and in many parts of this region, with irrigation, the same shade trees and ornamental plants may be grown as in the eastern states. The elm, buckeye, horsechestnut, the maples, oaks, the locust (*Robinia pseudacacia*); the honey locust (*Gleditschia triacanthos*), as well as all the trees grown in the other sections of the state, can be grown here without difficulty. The Lombardy poplar and the Carolina poplar appear to be favorite trees of the Bitter Root region and the Balm of Gilead is everywhere planted, while the two species of ash, the mountain ash, the willows and birches with the evergreens of common cultivation are more or less frequent.

All the ornamental vines mentioned in the first group will do well here and in addition a large number, if not all of those found adapted to Massachusetts, New York or Michigan, provided sufficient water can be supplied during the drier parts of the summer. Although I am not aware that any experiments have yet been made, there is no climatic reason why the Boston ivy

(*Ampelopsis tricuspidata*), the various honeysuckles including our native species (*Lonicera ciliosa*), the bittersweet (*Celastrus scandens*), the Aristolochia, the various species of clematis, the matrimony vine (*Lycium Chinense*) and even the grape should not be made grow in many localities with proper care.

4. MOUNTAINS above 5,000 feet. Curiously enough this line limiting the successful growth of crops, such as wheat, oats and potatoes, appears to be some 2,000 feet higher east of the Continental Divide than west of it in the Flathead region, although further south this line of climatic stress rises till at Deer Lodge and in the Bitter Root valleys it is nearly the same on both sides of the range, (5,000 feet).

There are many mining towns and camps and a number of summer resorts above this line of cultivation, which also limits the growth of most of the shade trees. Here it will be necessary to fall back upon the native trees, as few introduced species can stand the climate. The Balm of Gilead can be grown successfully up to 6,000 feet, or even to 6,800 in the mountains in the plains region. The quaking asp (*Populus tremuloides*) can be grown in wet situations up to 8,000 feet, but is best used to form groves about springs or to form shelters for dwellings in the more exposed situations. In the lower situations near this line the native alder (*Alnus tenuifolia*), and birches (*Betula papyrifera*) and (*B. occidentalis*), the mountain ash (*Pyrus*), the native willows and the various species of native pine, fir and spruce will furnish a fair variety for shade, shelter and ornamentation, while the beautiful native flowering clematis (*Clematis Columbiana*) can be made to trail over verandas, fences and shrubbery in a way that cannot be done at lower altitudes, while irrigation will rarely be found necessary except on the drier mountain sides. It is probable that the cut-leaved birch (*Betula alba laciniata*) and the pendulous mountain ash, as well as many of the spruce, firs and other cultivated conifers can be planted successfully.

As yet, this ornamental planting is confined largely to the cities and towns possessing water-works or an irrigation system, but there are many country homes that rival these city habitations; yet it is surprising to see how few houses and yards even in the larger towns and cities have these beautiful

natural protections from the heat of summer and the bleak winds of winter and their absence can be explained only on the false assumption that the usual shade trees and vines will not grow in this climate and that native trees are undesirable.

WORK AS LIBRARIAN.

In addition to my work as botanist, it has also fallen to my lot to act as the librarian of the Station. I have had general charge of the work of completing the various sets of state and governmental publications received by the Station and am glad to report that in addition to the forty-six volumes of the Bulletins and Reports of the various Experiment Stations of the different states bound last year about 180 more volumes have recently been completed and sent to the binder, so that, although a number of them yet remain more or less imperfect, we shall have an almost complete set of these valuable publications for consultation in the work of the Station. In addition complete sets of the bulletins of this Station have been sent to every public library in the state, so as to make them more available to the general public. This is now the more necessary as many of these bulletins are out of print and it was only with the greatest difficulty that sufficient numbers were obtained to complete these several sets. In order to make the various subjects embraced in our publications more accessible, an index covering the entire period was prepared for Bulletin No. 28 and has been continued in each annual report succeeding. I have also had general oversight over the work of mailing the bulletins of the Station and I would recommend that the mailing list be printed and the mailer be used throughout for the work of issue. One other pressing need for the Station library is that all the books belonging to the Station be properly labeled and catalogued with a card-index of titles and subjects, as this would make available a great mass of special agricultural literature now unknown and needed for the work of the several departments of the Station.

ENTOMOLOGICAL DEPARTMENT.

R. A. COOLEY, Entomologist.

The experiences of the year have shown the great need of entomological research in Montana. A large amount of damage is being done by native insects, and very little light, comparatively, has been thrown on their habits and the ways to combat them, many species never having received more than passing mention in entomological literature. These, as well as many introduced species, well known elsewhere, for their destructiveness, demand attention in order that their habits may be worked out and remedies or preventive measures devised.

Montana is enjoying with the rest of the country a season of almost boundless prosperity, parallel with which is a great mercantile activity. Many heavily loaded trains bearing agricultural products and merchandise cross our borders from the outside each day. The invariable experience of the past has been that such mercantile practices are responsible to a great extent for the spread of injurious insects from one country or section to another. We do not hesitate to say that many insects are being deposited in the state from other places each year.

The following list gives the names of species that have been detected in the state and which are believed not to be native of Montana:

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- The apple leaf-aphis, *Aphis pomi* De G.
The currant aphid, *Myzus ribis* Linn.
The cherry aphid, *Myzus cerasi* Fab.
The plum aphid, *Aphis pruni* Fab.
The lettuce aphid, *Nectarophora lactucae* Kalt.
The cabbage aphid, *Aphis brassicae* Linn.
The elm gall-aphid, *Schizoneura americana* Riley.
The hop aphid, *Phorodon humuli* Schr.
The rose aphid, *Nectarophora rosae* Linn.
The grain aphid, *Nectarophora granaria* Kirby.
The oyster-shell barklouse, *Mytilaspis pomorum* Bouche.
The bedbug, *Cimex lectularia* Linn.
The rose "thrips," *Typhlocyba rosae* Linn.
The carpet beetle, *Anthrenus scrophulariae* Linn.
The plum curculio, *Conotrachelus nenuphar* Linn.
The larder beetle, *Dermestes lardarius* Linn.
The Colorado potato beetle, *Doryphora decemlineata* Say.
The house fly, *Musca domestica* Linn.
The horn fly, *Haematobia serrata* Rob.-Desv.
The gooseberry fruit worm, *Dakruma convolutella* Huber.
The codling moth, *Carpocapsa pomonella* Linn.
The bud moth, *Tmetocera ocellana* Schiff.
The case making clothes moth, *Tinea pelionella* Linn.
The cabbage plutella, *Plutella cruciferarum* Zell.
The strawberry leaf-folder, *Phoxopteris comptana* Frohl.
The currant stem borer, *Sesia tipuliformis* Clerck.
The European cabbage butterfly, *Pieris rapae* Linn,
The red humped apple-tree caterpillar, *Oedemasia concinna*
S. & A.

The cigar case bearer, *Coleophora fletcherella* Fern.

This list is not designed to be complete but contains, rather, such species as have come prominently under notice.

It is sometimes noticeable that native species which have transferred their attack from indigenous plants to introduced ones, are markedly destructive. Some of our most injurious species are natives of this section and occur in great numbers in the open country. The strawberry weevil that is doing such disastrous work in the Rattlesnake valley is an example of this class.

This beetle (*Otiorhynchus ovatus* Linn.), while occurring generally in the state, appears in enormous numbers locally. One such colony was found in the Bitter Root valley far away from any strawberry fields. Were strawberries to be planted in this vicinity they would doubtless be completely wiped out.

The number of native injurious species is very large. Among the more prominent ones that have been recorded at this office are the following:

The rosebud curculio, *Rhynchites bicolor* Fab.

The strawberry root weevil, *Otiorhynchus ovatus* Linn.

Wire worms in grain, *Elateridae*.

The spotted blister beetle, *Epicuta maculata* Brunner.

Various shade tree borers, *Cerambycidae*.

The willow leaf beetle, *Lina scripta* Fab.

The potato flea beetle, *Epitrix cucumeris* Harris.

The willow flea beetle, *Crepidodera helxines* Linn.

Poplar aphids, (at least five species) *Aphidae*.

The woolly aphis of the apple, *Schizoneura lanigera* Hausm.

The pine leaf scale, *Chionaspis pinifoliae* Fitch.

Putnam's scale, *Aspidiotus ancylus* Putnam.

The western Pulvinaria, *Pulvinaria innumerabilis occidentalis* Ckll.

Many leaf hoppers, *Jassidae*.

The tarnished plant bug, *Lygus pratensis* Linn.

The boxelder plant bug, *Leptocoris trivittatus* Say.

The American roach, *Periplaneta americana*.

Many species of locusts, *Acrididae*.

The native currant fly, *Ragoletis ribicola* Doane.

The tent caterpillar, *Clisiocampa erosa*.

The army cutworm, *Chorizagrotis agrestis* Groate.

Many other cutworms, *Noctuidae*.

The cabbage plusia, *Plusia brassicae* Riley.

Various ants, *Formicidae*.

The poplar leaf-folding fly, *Pontania* (?) sp.

The clover mite, *Bryobia pratensis* Garm.

The pear-leaf blister-mite, *Phytoptus pyri* Scheuten.

Not an insect has been mentioned in the foregoing lists that has not undiscovered facts of greater or less importance concern-

ing its life-history. The pressing need in economic entomology in Montana, as elsewhere, is the unravelling of the life stories of the injurious species, and a scarcely less urgent demand exists for a knowledge of the habits of the parasitic and predaceous species of which Montana has a liberal share.

Early in the spring it was found that the entomologist could not meet the demands for his services in repressing insects about the state and satisfactorily conduct his classwork at the same time. Accordingly an appeal was made which resulted in the appointment of Miss Edna Maynard, a graduate of the College in the class of 1901, as temporary assistant in teaching. We were then able to co-operate with the State Board of Horticulture in controlling the codling moth in Missoula and vicinity. This co-operative work has occupied a great deal of the time of the entomologist but has yielded ample results. The city of Missoula was the headquarters for an investigation into the situation in that vicinity as to the codling moth and incidentally many other insects. A cage was erected over an entire apple tree and the habits of the codling moth were studied as well as they could be, considering that the cage is 222 miles from Bozeman and the entomologist had to be in Bozeman the greater part of the time. The visits to the cage were carefully timed and reliable results were obtained by making use of local assistance. It is desirable that a similar form of co-operation be followed in the future since the work of the Board of Horticulture, in many particulars, is identical with that of the entomological department of the Experiment Station.

A series of sealed boxes of specimens of some of the most important injurious insects was prepared and given out about the state. The results of this experiment seem to warrant the preparation and distribution of other boxes as fast as the necessary specimens can be secured. The writer was told by the proprietor of a hotel at Missoula, where one of the boxes was placed, that for a period of something like two months not a day passed without from two to five persons coming to the office for the purpose of examining the insects.

There are many lines of work needing attention which will be taken up as rapidly as possible and in the order of urgency. The following may be mentioned:

Mosquitoes:—There are many parts of the state, that, according to the reports reaching the Station, are so badly ridden with mosquitoes at certain seasons of the year as to make life miserable for man. It is desirable to look into the conditions in these places and see if some measure of relief cannot be secured. We are already collecting the species as fast opportunity is presented.

Grasshoppers:—During the past three years many complaints of loss by grasshoppers have reached the Experiment Station. Ranges have been so devastated that the herds have been obliged to leave them and go elsewhere. The summer of 1902 was a notable one for the destruction wrought by grasshoppers in Carbon and Yellowstone counties. It is desirable to familiarize the ranchers with the methods used in older states or devise new ones for the wholesale destruction of these pests where feasible.

Plant Lice:—A large number of species of plant-lice occur throughout Montana many of which are attracting the attention of the ranchers and general public. A considerable number of species were collected during the past summer and the office contains notes on file.

Insects of Alfalfa:—Alfalfa is a favorite crop in Montana, being sure and very productive. Some of the older fields have been in this crop for nineteen years without being broken up. Such conditions are favorable to the development of many insects. Various reports of devastation of this crop have reached us. Grasshoppers are accused of doing great injury.

Flea-beetles:—Flea-beetles are very abundant in point of species and number of individuals, in the state.

Fruit Insects:—Besides the species injurious to fruits that are already under investigation, there are many others working their destruction unmolested. This office has accumulated notes on this subject that will soon be made public.

We present below an account of four species of insects that deserve attention on account of their prevalence in Montana fields.

THE COTTONWOOD LEAF-BEETLE.

Lina scripta Fabr.

This insect has often been reported to the entomologist as being very destructive to both the cottonwood and willow. Not only has

it been destructive to these trees along river courses and other remote places but also to cultivated trees.

It is in the larval stage that most of the injury is done. The leaves are completely skeletonized and die from the effects.

The eggs are laid on the foliage in clusters similar to those of the Colorado potato beetle which is a member of the same natural family of beetles, the Chrysomelids, a family well known for their destructiveness to the foliage of plants. The eggs hatch into larvae which at first are black, but which later become yellowish. The legs are glossy black and there are two longitudinal rows of black spots on the back. On each side of the body is a row of black tubercles which produce a milky fluid with a pungent odor which is a source of protection against enemies.

The beetles crawl to the stems to pupate, and attaching the posterior end suspends the body in the air, the pupa remaining partly protruded from the larval skin.

The beetles are oval, more flattened than the Colorado potato beetle and are from two to three-tenths of an inch in length. The head is black and the thorax black and red or yellowish. The beetle is variable in the markings of the wing-covers. All the specimens in the collection of the College, from various parts of the state, show the ground color to be the usual dull yellowish with uniformly seven spots and lines on each wing cover.

In other parts of the United States there are two to three broods of the insects each year. Montana probably has two broods only.

REMEDY.

Paris green as a spray on the foliage, using one pound to 100 gallons of water, is a good remedy. This will kill both the larvae and the adults.

The species is a native one and it is therefore not wise to attempt to exterminate it.

THE CUCUMBER FLEA-BEETLE ON POTATO.

Epitrix cucumeris Harris.

This minute beetle was taken by the writer in a potato field at Missoula where it was present in almost incredible numbers, hav-

ing completely skeletonized the foliage in many places. Being a native species it may appear at any place in Montana where potatoes are grown.

While this insect is popularly known as the cucumber flea-beetle, it has oftener been reported from the potato and tomato, and is well known for its injuries to many other plants, among which are, corn, apple, tobacco, egg plant, celery and pepper.

The larvae feed on the underground parts of the plants which the beetles attack. They are elongated whitish grubs, minute in size and not often observed by the farmer. These larvae sometimes attack the tubers and roots of the potato and are thus responsible for the production of imperfect potatoes and weakened plants.

The beetles measure about one-twelfth of an inch long and are black with reddish-brown antennae and legs. They are very active and difficult to catch. The posterior legs are fitted for leaping, and when disturbed they jump, and, because of their small size, are lost sight of.

REMEDIES.

Bordeaux mixture and a little Paris green or slacked lime and Paris green is a good remedy. These should be applied as a spray and with thoroughness.

MEALY-BUG ON APPLE AND PEAR.

Dactylopius sp.

While searching for codling moth pupae under the scales of bark of the apple trees of Missoula in January, 1902, numerous cottony masses of this insect were found. So far as has yet been observed the insect is not of great economic importance in Montana except that it is very liable to be mistaken for the cottony masses of the woolly aphis. This mistake is much more liable to be made on account of the fact that during the summer months the mealy-bug, like the woolly aphis, prefers scars and injured places on the bark. During the summer these insects were found very commonly in Missoula, usually in bunches but often crawling about over the trees.

REMEDIES.

Should this insect become so abundant as to be injurious it may be held in check by treatment in the winter in the following manner:

Scrape off the loose outer bark, and wash the trunks and larger limbs with whale-oil soap solution, one pound in one gallon of water.

Many of the specimens brought to the office were found to have been killed by parasites.

AN ANT AS A FRUIT PEST.

During the writer's frequent visits in the Bitter Root valley a number of complaints reached him concerning a small ant that builds its colonial mounds about the trunks of the apple trees and girdles them. Many colonies were found in the one orchard examined that were not at the bases of the trees but the ants showed preference for this position. Trees in these mounds were either killed or greatly injured as a result of the girdling of the stem. Inquiry made at different places in the valley showed that the trouble is a common one.

REMEDY.

The use of the bi-sulphide of carbon, pouring it into the openings of the mounds and later closing the openings with earth, would probably be a satisfactory remedy.

The writer has had good success with this substance used against ants in the lawn and in other species but has never used it against this ant.

The substance is very inflammable, a lighted cigar being enough to ignite it. The confined vapor is explosive. Care should therefore be exercised with its use.

In treating lawn ants we have set fire to the vapor as it escapes from the openings, and have made the destruction of the ants more thorough. It would be well to experiment with this method also in the control of this ant, to see if any injury will result to the tree.

Only a small amount of the bi-sulphide of carbon is necessary.

HORTICULTURAL DEPARTMENT.

R. W. FISHER, Assistant Horticulturist.

The work in this department for the year ending November 30 has been along the following lines:

A study has been made of the cultivated trees in this vicinity for the purpose of finding ornamental shade trees to replace the poplar or the cottonwood. Several trees new to this section have been introduced and are now growing in the Station nursery. The work already instituted of testing fruit trees for their hardiness has been carried on, and the quality and quantity of the different varieties of apples has been noted.

Variety tests of the common garden vegetables were made with the intention of finding those best adapted to our conditions, and the different varieties of small fruits were compared as to yield, quality of fruit and hardiness.

FOREST AND ORNAMENTAL TREES.

It is a lamentable fact that with the very large timbered area we have in this state, so few trees are to be found outside the natural forest belts, which for the most part are wholly within the mountain ranges and therefore afford but little immediate benefit to the larger class of citizens who spend most of their time on the farms or in the cities.

Believing that the planting of ornamental trees should be given more attention than in the past this department has attempted to introduce the trees usually grown in the states, whose climatic conditions are somewhat similar to ours; and accordingly last spring several different varieties including oaks, elms, maples, linden, etc., were set out in the Station nursery with the intention of testing them for their hardiness and general adaptability to our soil and climate. This experiment will necessarily have to extend over a period of several years, as it is impossible to tell from one year's growth whether or not a tree is worthy of being generally planted.

In many cases when trees are imported into the state from lower altitudes and milder climates they are not perfectly hardy, whereas if they were grown from seed here they would in all probability prove hardy enough to stand our winters without injury. In order to test this thoroughly, tree seeds are being collected and will be planted as soon as practicable.

I find a record of there having been planted in 1895 a number of different trees, and it is thought fitting that mention be made of them in this place as they show some interesting facts in regard to the hardiness and general adaptability of certain trees to our climate and soil.

The following table gives in detail the data gathered concerning these trees. All the deciduous trees set in 1895 were seedlings, one year old, about twelve inches high; The conifers were two and three years old and from six to twelve inches in height.

Common Name	Scientific Name.	Time Set.	Height	
European Alder	<i>Alnus glutinosa</i>	1895	...	Kills back each winter
Mountain Ash	<i>Pyrus aucuparia</i>	1895	11 5	Very
Silver Maple	<i>Acer dasycarpum</i>	1895	10 4	Not p
European White Birch	<i>Betula alba</i>	1895	17	Fine
American Elm		1895	11 5	Very
Catalpa		1895		All de
White Ash	<i>Fraxinus americana</i>	1895	9 6	Good trees; perfectly hardy
Green Ash	<i>Fraxinus viridis</i>	1895	9 9	Hardy
Bur Oak	<i>Quercus macrocarpa</i>	1895	7 7	Hardy; slow growth but will make good trees
Black Walnut	<i>Juglans nigra</i>	...		Seedlings. Not hardy; foliage killed by summer frost
European Larch	<i>Larix Europea</i>	1895	12	Hardy

EVERGREENS.

Common Name.	Scientific Name.	Time Set.	Height	
Colorado Blue Spruce	<i>Picea pungens</i>	1895	5 4	Hardy; beautiful trees
Scotch Pine	<i>Pinus sylvestris</i>	1895	...	All have died
Douglas Spruce	<i>Pseudotsuga taxifolia</i>	1895	7	Hardy; comparatively rapid grower
Red Pine	<i>Pinus resinosa</i>	1895	...	All have died
Mountain Pine	<i>Pinus montana pumila</i>	1895	4 5	Hardy; rather slow grower
White Spruce	<i>Picea alba</i>	1895	8 6	Hardy; good trees, fast grower
Red Cedar	<i>Juniperus virginiana</i>	1895	4 5	Hardy; desirable for hedges
Norway Spruce	<i>Picea excelsa</i>	1895		All have died
White Pine	<i>Pinus strobus</i>	1899	1 8	Apparently hardy; slow growth
Austrian Pine	<i>Pinus Larico Austriaca</i>	1899	2 5	Hardy
White Fir	<i>Abies concolor</i>	1895	5 2	Hardy; very pretty tree
Arbovitæ	<i>Thuja occidentalis</i>	1895	4	Hardy; good hedge plant

From the above table it is seen that the elm, oak, white birch, mountain ash, European larch and the white and green ash are hardy among the deciduous trees; while the hardy list of evergreens includes the Colorado blue spruce, white fir, red cedar, mountain pine, Douglass spruce, and arborvitae.

Several varieties of poplars are growing on the Station grounds the best of which, for shade or ornamental purposes, is the Carolina.

Many failures to grow ornamental trees other than poplars are not always attributable to winter killing as is often thought, but are quite as often due to entirely different causes.

Trees cannot be expected to grow vigorously unless care is taken in the preparation of the ground before planting. The trees should be properly set out and given good cultivation and care until the root system is thoroughly established. Winter killing can often be prevented in many cases if care is taken that the wood is thoroughly ripened before freezing weather. This is accomplished by forcing the growth early in the season by good cultivation and irrigation and withholding water and ceasing deep cultivation as the season advances. If plenty of water be given until the middle or last of July and then withheld, the trees will make a normal year's growth and will have time to ripen their wood before cold weather comes, thus being better able to endure a much colder temperature than they otherwise would.

ORCHARD TREES.

The first trees of the Station orchard were planted in 1895 and as it was at that time mostly experimental work, many varieties set were destined to die, not being hardy enough to endure the winters. Since that time other varieties have taken the places of those that died; sometimes hardy and as often tender trees being planted, and the result is that the orchard presents a very uneven appearance in the size and age of trees. Of the 64 varieties of apples set in 1895, but 26 are now alive; and of these 26 varieties but about eight are worth growing. The others being of an inferior

quality of fruit. The best varieties are: Wealthy, Yellow Transparent, Duchess de Oldenberg, Okabena, Hiberna, Tetofsky, Longfield and Gideon. Ten varieties of crabs were set in 1895 and eight are now alive. Of these the best are: Whitney No. 20, Transcendent, Greenwood, Hyslop and Orange. The Moldavka and Yellow Veronesch plums are the only ones out of 30 varieties planted in 1895: Three cherry trees out of 14 are now alive and last year produced a moderate yield. These are: Sklanka, Griotte du Nord and Bessarabian. Flemish Beauty is the only pear alive of 16 planted in 1895. This tree has produced no fruit yet; however, the tree seems quite vigorous, although it has not made as large a growth during the time since it was set out as would naturally be expected.

SMALL FRUITS.

Raspberries:—To be successful with this class of fruits, some winter protection is necessary. When about six bearing canes are grown in each hill, and the hills 4 x 6 feet apart, it is quite easy to lay them down and cover with dirt or straw. By doing this a good yield is assured, other conditions being favorable. This applies equally well to both the red and black raspberries, except that more care must be taken when handling the black varieties that they are not broken while being bent over. There are some seasons in which no winter protection is necessary, notably the winter of 1901-02, but it is better to be on the safe side and cover each winter, as the time and expense in doing this is more than repaid by the quantity of fruit produced. The red varieties can be bent over without disturbing the roots if handled before being frozen; but the best way in which to treat the black varieties is to plow a furrow near enough the row so that the plants can be bent below the roots, otherwise the canes are likely to break while being bent. The leading varieties from the standpoint of fruit production and marketable qualities are in the order given as follows, Marlboro, Cuthbert, Hansell and Brandywine. The Cuthbert is not as hardy as the others, necessitating more careful covering during the winter, but the yield and quality of fruit is superior to all except the Marl-

boro. The black varieties are not as hardy as the red ones and many failures are due to the fact that insufficient or no protection is given, and to be successful with this fruit it is absolutely necessary to give some winter protection.

Strawberries:—Splendid, Bisel, Bederwood and Crescent still lead in productiveness and quality of fruit.

Currants:—Fay's Prolific, Red Dutch, Victoria and North Star have been tested here, The Fay is much the largest berry, but does not give as large a yield as does the Victoria.

Currants are one of the easiest crops to grow, being perfectly hardy and producing large crops each year. The best success is obtained when the bushes are planted in rows six feet apart, with the plants about four feet apart in the rows. The cultivation should be shallow as they are surface feeders, and the bushes should be pruned each year, enough to keep out all dead branches and old wood. They thrive best on a rich, loamy soil, but will grow on a large variety if given care. It is best to plant them in a location where the snow will not drift over them as it often breaks the branches and the alternate freezing and thawing of the snow is detrimental to the bushes.

Gooseberries:—But two varieties of gooseberries have been grown here—the Industry and Downing, the leading English and American varieties respectively. Both were badly affected with the gooseberry mildew, it being much worse on the Industry than on the Downing.

Many people in this section will not attempt to grow this berry at all on account of this disease because unless the bushes are sprayed the mildew spoils the crop. Potassium sulphide is the best known substance to spray with, and when properly applied will entirely hold this disease in check.

Dissolve the potassium sulphide in water at the rate of one ounce in two gallons of water and spray early in the season about the time the buds begin to swell, and at intervals of about ten days thereafter. This is a very effective treatment and is comparatively cheap.

GARDEN CROPS.

Variety tests of common garden vegetables were made for the purpose of determining if possible the varieties best suited to our

conditions. While one year's test cannot be taken as conclusive, yet the results in many cases show those varieties best adapted to our climate, and also show those wholly unfit for cultivation here.

Beans:—Forty varieties of beans, consisting of fourteen dwarf green-podded, eleven dwarf wax, five bush limas, five pole limas and five pole snap beans were tested.

All except the dwarf green-podded and the dwarf wax were killed during the latter part of June by frosts. These also were badly frosted but recovered and in most cases ripened. The following table gives the result in detail:

DWARF GREEN PODDED.

VARIETIES.	Yield in lbs. per Ac.	.
Early Warwick	396.4	Mature
Extra Early Refugee	476.2	Mature
Refugee or 1,000 to 1 .....	.....	Did not mature
White Marrow	315.5	Fairly well mature
Longfellow	400	About half mature
Early Mohawk	300	Mature
Henderson's Bountiful	792.3	Mature
Henderson's Early Red Valentine	513	Mature
Burpee's Brittle Wax	623.9	Mature
Henderson's Black Valentine	521.7	Poor beans
Henderson's Cream Valentine	334.6	Mature
Dwarf Horticultural	692.9	Mature
Large White Kidney .....	.....	Not mature

DWARF WAX.

VARIETIES.	Yield in lbs. per Ac.	
Golden Wax	595.8	Mature
Valentine Wax	592	Mature
Golden Eyed Wax	217	Mature
Improved Golden Wax	348.8	Mature
Improved Black Wax	354.4	Mature
Keeney's Rustless Golden Wax .....	.....	Not mature
Refugee Wax	630	Mature
White Seeded Wax	677.9	Mature
Flageolet Wax	412.8	Mature
Wardwell's Kidney Wax	647	Mature
Yosemite Mammoth Wax	110.6	One-third mature

Beets:—This root will do well in any rich, warm soil, but prefers and does its best in a sandy loam. Six varieties were tested, Crosby's Egyptian, Eclipse, Electric, Lentz, Henderson's Half-Long and Edmonds. Crosby's Egyptian is the earliest and gave the largest yield but is excelled by Henderson's Half-Long in quality and market requirements.

Cabbages:—Cabbages form an important crop both for the home and market garden, and in either case two crops are generally grown, the early or summer, and the winter cabbages. The plants for the early cabbages are started in hot-beds or boxes early in the spring, and after being hardened by exposing to cooler air than that in which they have been growing, they are transplanted into the open ground after danger of hard frosts is past. After the first few days they require no special treatment; that given other vegetables being sufficient.

The late crop is grown in much the same way, except the plants are not started or set out until much later in the season, and the mature heads being much larger than the early varieties, they require more room.

The varieties giving the largest yields of those tested are as follows: Early cabbage; Succession, Early Spring, Early Summer, Early Stone Head and Early Jersey Wakefield. Late; Holland, Late Stone and Late Flat Dutch.

Celery:—The climate and soil of Montana is particularly adapted to growing a very fine quality of celery and this crop bids fair to become an important garden product of the farm. The demand for this vegetable is so large that the local dealers have to depend upon outside growers for the most of their supply; and if people from a distance can grow celery and sell at a profit in our home markets, surely the Montana gardener can realize a good margin of profit on his crop.

Trials made at the Station and by local private gardeners demonstrate that celery of first class quality and in paying quantities can be successfully grown. For the early crops the self blanching varieties are the best, although not as large as some others. The Giant Pascal proved to be the best late variety, producing large stalks of very fine quality.

SUB-DEPARTMENT OF POULTRY.

H. C. GARDINER, Student in Charge.

ARTIFICIAL HEAT IN POULTRY BUILDINGS.

Our experience with artificial heat during the past winter has been very satisfactory. It is popularly supposed that the use of artificial heat in poultry buildings affects the vigor of the fowls to such an extent as to make them liable to colds and very susceptible to disease. This is no doubt true of many instances in which artificial heat has been used carelessly. The use of artificial heat is a direct saving in feed, we know that in order to maintain animal heat and carry on the different functions of the body a certain amount of fuel in the form of feed is required, and further as the outside temperature is lowered a larger amount of fuel is necessary and the food material which might be used in egg production has to go towards maintaining the animal heat of the body. The point is this, the digestive apparatus of a hen can only accomplish so much and if all the energy has to go towards maintaining the animal heat of the body with no return the fowl in cold weather becomes a source of increased expense. Further, coal or wood are both much cheaper for keeping fowls warm than grain.

In heating a poultry house special attention must be given towards securing an even temperature, the chief need for heat is on cloudy days, during cold snaps and at night. In a properly con-

structed house very little fire should be maintained during the time the sun is exerting its influence and the endeavor should be to avoid a temperature above 55 degrees and as near as possible to secure an average of about 45 degrees to 50 degrees: The most successful method of heating poultry buildings and the only practical method for poultry plants is a hot water pipe system, but for the average building a small stove serves the purpose admirably. The stove should be one which will hold fire for eight or ten hours and which can be easily regulated for a slow fire. It should not be placed where the fowls can get close to it but preferably in the hallway or passage outside the pen. From our observations we conclude that it is not possible to ventilate a poultry building properly in cold weather and at the same time maintain a temperature above freezing. Further, under the average conditions fowls will be healthier when kept in buildings properly heated for this reason, they will avoid extremes of heat and cold. In the average house on a sunny day where there is a considerable area of glass in the front, the temperature goes way up and at night way down, with proper ventilation the maximum would not be excessive and with a fire at night the other extreme would be avoided.

SHADE FOR YARDS.

The advantage of changing the location of poultry yards, both pens in which old birds are kept, as well as those in which young ones are raised, is well known. The facility, too, with which these yards may be plowed up and cultivated add to their usefulness in obviating the dangers of disease and also make them additionally valuable in the production of forage for fowls. An essential feature too, in providing yards is to provide shade and to secure it from some annual plant rather from a tree or shrub which could not be sown in a new place and which would restrict the thorough working of the land. We have found that in the Mammoth Russian Sun Flower almost an ideal plant is secured. It makes a quick vigorous growth, reaching a height of from six to twelve feet, provides dense shade, is easily sown, is not eaten off by the fowls when

young and tender, and when mature provides a nutritious food which makes a particularly valuable addition to the ration, ripening as it does just at the moulting season. In feeding sun flowers there is no need to harvest them. If the stalks are broken in the middle the fowls will do the rest of the business. From our experience we would advise planting the sun flowers in one end of the yard, if it is desired to grow forage, since a forage crop will not do well where the sun flowers are grown thick enough to provide dense shade. On the other hand where fowls are not penned but have a free run, clumps of sun flowers in convenient places serve better than one large patch.

The question of shade is of particular importance in our state since we have such a large proportion of sunny weather, and further, since any provision for shade is found to be lacking in almost every place in which fowls are kept. Another advantage worthy of mention is the shelter afforded by dense clumps of sun flowers from hawks. In our open runs hawks work a serious havoc and the protection afforded by such cover minimizes the danger.

FORAGE FOR POULTRY.

During the summer months a supply of green forage is very essential for poultry, in fact, they will thrive on good clover pasture with but a small addition of grain. We have advised in earlier publications grading poultry yards with a view of irrigating them when sown with clover or some grain mixture and further advise, where possible, having yards on either side of the house so that one portion could be pastured while the other side was being irrigated and growing another crop. It is not possible in yards of small size for clover or other forage plants to exist under the close cropping of the industrious hen; but where pens can be arranged on both sides of the house and water can be had, abundant pasture can be secured for 25 birds on one-tenth to one-twelfth of an acre of good soil.

There are several advantages to be derived from the double pens, the irrigation thoroughly renovates them. More birds can

be kept on a given area and the change to fresh, clean pasture is beneficial to the health of fowls.

When permanent pastures are required white clover is the ideal plant. It will withstand the pasturing better than the other clovers, and the plant itself, owing to the fineness of the leaves, is better suited to feed. From the standpoint of feeding value the white clover is ahead of any other plants which may be used for forage purposes. It is not, however, of much value for the first season it is sown and the fowls must not be allowed to run on it until the plants get a good start and form a reasonably close mat.

Where forage is wanted early in the season and where it is not convenient to start a permanent pasture oats serve the purpose. We urge strongly that abundant forage be provided for fowls for two chief reasons, it forms a cheap and valuable addition to the ration and further insures a healthy digestive system.

BROWN LEGHORNS.

The special adaptation of the Brown Leghorns to the market needs and the climatic conditions of our state has impressed us with the fact that they are above all others the utility fowl for Montana. The breed, however, possesses one feature of disadvantage, and that is the large comb and wattles found in both single and rose combed varieties. Large combs and wattles and even medium sized combs and wattles will freeze unless special care is taken to prevent it. When a laying hen's comb is frozen she, to all practical purposes, becomes diseased and her laying stops. Feed and care are then wasted and what was a profitable investment becomes an expense. Rose combed fowls do not escape the danger of frost bite for their wattles will freeze as readily as the single comb variety and it is as serious for wattles to freeze as for the combs. In fact, where fowls run out in the winter and get their wattles wet in the drinking water the wattles are more liable to freeze than the combs.

This undesirable feature can be very easily overcome. We have in three years been able, by purchasing small combed roosters and cutting out the hens with the largest combs, to reduce the average size of the comb more than one-half. Three years more of such

selection and we will have a fowl with such small comb and wattles that there will be no possibility of their freezing under any reasonable circumstances. We would strongly advise all who secure stock from the east for breeding purposes to purchase specimens with small combs and those who breed from birds of their own raising would increase the value of their future flocks materially by selecting the smaller combed specimens while, of course, giving due attention to the other essential qualities.

The large combs are merely a matter of fancy and are only suitable to warm climates. Raising fowls with such appendages is on a par with attempting to grow tropical plants at our latitude.

POULTRY FENCES.

During the last year we have completed permanent fences around our main poultry building and from our experience offer a few suggestions. Some permanent form of fencing is desirable, and necessary about all poultry buildings and essential where pure bred stock is kept and pens are kept separate during the breeding season. Poultry netting well galvanized and 72 inches wide is the only satisfactory fencing material, and in order to stretch it properly a scantling should be mortised on edge in the top of the posts for a top rail. Posts are best set eight feet apart using 2x4s sixteen feet long for tops. In order to make the fence as lasting as possible we charred the butts of the posts and filled in the holes with rock and cinders, also put about six inches of rock under each post. The posts should be sawed off five feet and a half from the ground and the netting buried six inches. This prevents fowls scratching and getting under the fence and also does away with a bottom rail or base board. In putting on the netting one end should be made fast with a double row of staples and the other end clamped between the 2x4s with bolts, and with a small wire stretcher attached to the middle, stretched up tight. The top wire should be then stapled on securely, and then by pressing down the bottom wire at each post and stapling to the post, the netting is deeply and tightly secured. In making gates, time and labor can be saved by stretching the wire on the fence and then setting the frame for the gate against the netting when it can be stapled to the gate without further stretching.

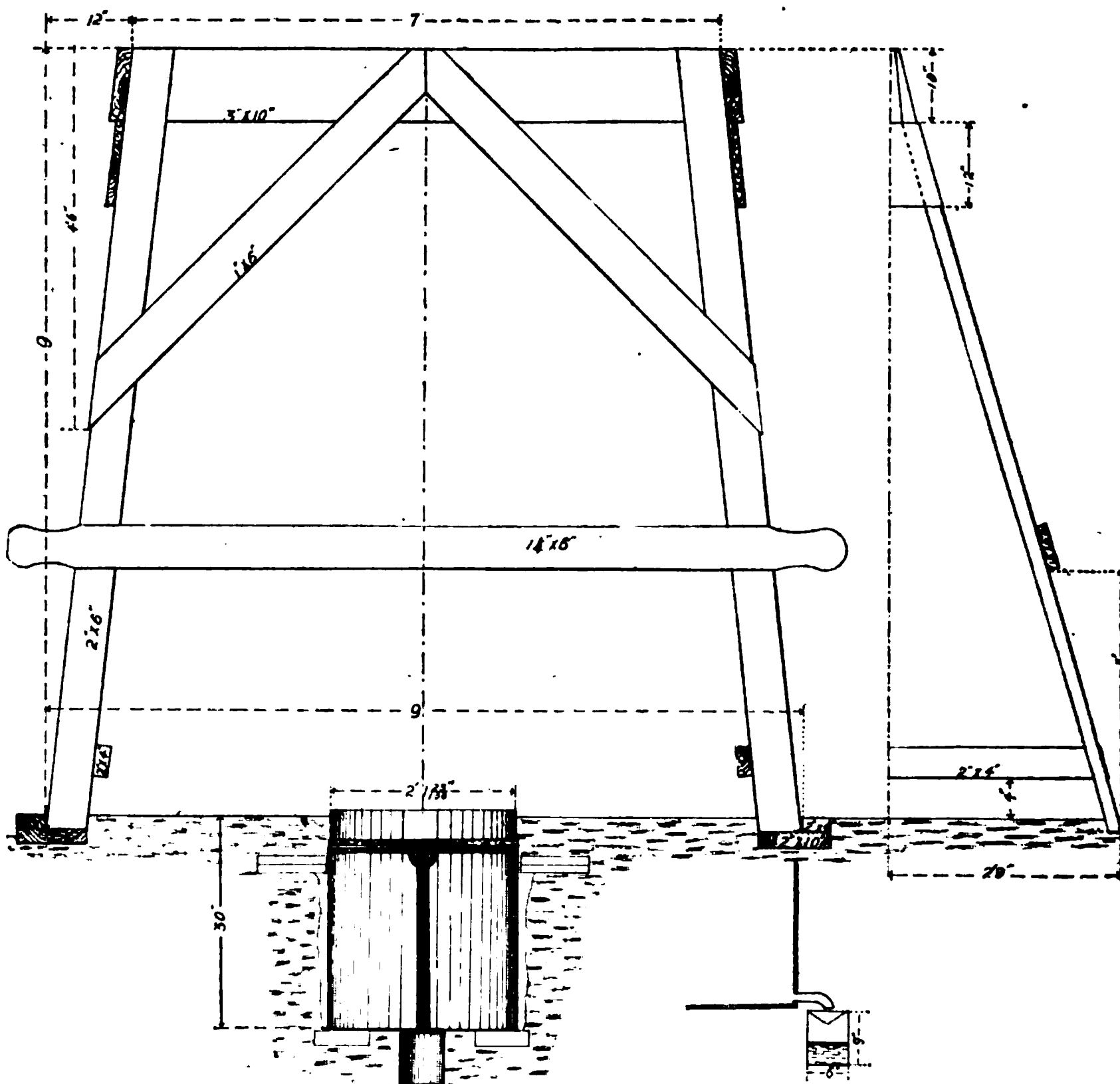
IRRIGATION DEPARTMENT.

S. FORTIER, Irrigation Engineer.

SOIL MOISTURE IN RELATION TO CROP YIELD.

A number of experiments have been tried to determine the effect of different amounts of soil moisture on the yield of farm crops. These experiments have been conducted for the most part under artificial conditions. On account of the difficulties to be overcome, few have been tried in the open field under ordinary crop conditions.

In the spring of 1897, when the writer was connected with the Utah Experiment Station, he had several tanks constructed of galvanized iron, filled with soil and placed in an open field nearly level with the surface of the ground. Figure 1 illustrates one of those vessels together with the wooden trestle used in raising it. Each tank was 30 inches deep and when filled with soil contained an area at the surface of 500 square inches. One tank was filled with water, three with bare soil and in the remaining eight the staple crops of that state were planted. A record was kept of the amount of water added to each tank which was weighed every ninth day. The writer had no opportunity to continue this line of investigation at that time, inasmuch as he severed his connection with the College and Station the following spring to accept the position of chief engineer of the Bear River Canal Company. The results obtained during the summer of 1897 proved conclusively that a larger amount of evaporation had taken place from the ex-



TANK AND TRESTLE
FOR
EVAPORATION EXPERIMENTS

FIG. 1

posed surface of the tanks than one would expect under field conditions. This was chiefly due to the fact that the earth around the tanks became quite dry and warm. Frequently also, open spaces were left outside of the tank and beneath the top covering, all of which increased the temperature of the metal tank and soil contents and produced greater evaporation. Experiments with the same tanks and hoisting device have since been made by the same Station and are reported in Bulletin No. 75. These later results seem to be open to the same criticism in that the conditions under which they were obtained were not normal.

In the spring of 1902, the writer found means and opportunity to resume the same line of investigations. In planning the work it was thought that the results would possess more value to the farmer if obtained under normal field conditions. The tanks were accordingly placed in an unoccupied part of the Station orchard. To prevent any obstruction to the free passage of the wind and the sun's rays as well as to afford a convenient method of hoisting and weighing the tanks, a one-half inch steel cable was stretched over supports 93.2 feet apart and 14 feet high. Differential pulley blocks were then suspended from a pulley on the cable and a strong bale and beam scale were attached to the blocks. Plate II shows the operation of weighing, while figure 2 gives the dimensions of the tanks and the mode of arrangement.

In order to lower the temperature in the soil surrounding the tanks and thereby decrease the amount of evaporation, the following device was adopted: Oak barrels were cut in half and placed in the manner shown in Figure 2, with their top edge about 14 inches below the surface of the ground. Gravel to the depth of a few inches was placed in the bottom and ordinary soil on top. Water was conveyed to the gravel through a $\frac{3}{4}$ -inch iron pipe. It was hoped that this device would not only lessen the temperature in the lower portion of the tank but that the water placed in the half-barrel would be drawn up by capilarity and evaporated at the surface, thus tending to cool the upper portion.

The metal tanks were first calipered and weighed and on May 23, 1902, they were filled with soil from the Station orchard, care being taken to place each layer of soil in its natural position within the vessel. The varieties of soil and subsoil are indicated

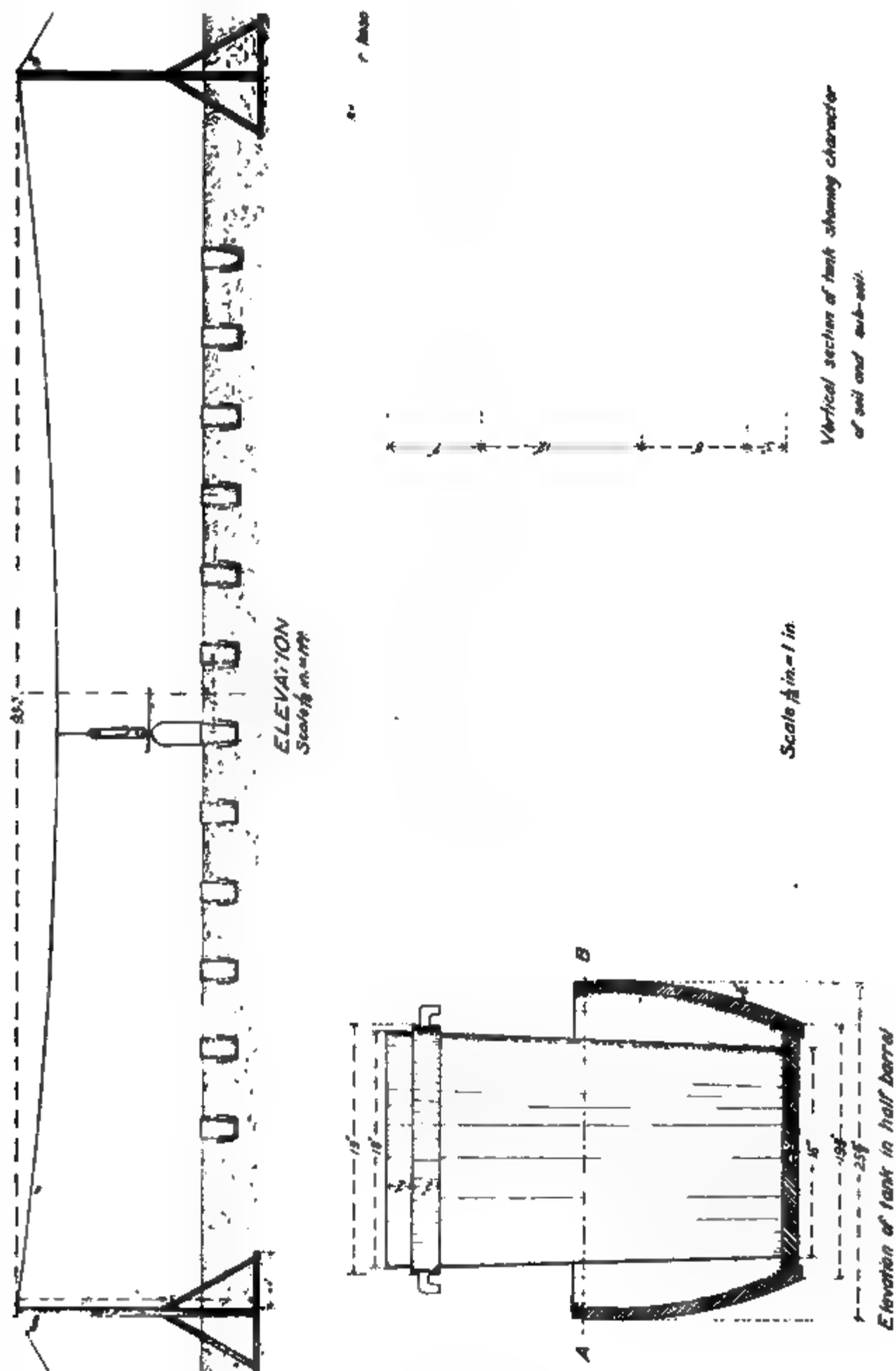


FIG. 2

in Figure 2. A piece of $\frac{3}{4}$ -inch hose was inserted for the purpose of conveying irrigation water to the bottom of each tank. The numbering was from right to left (Fig. 2) and on May 23, Nos. 1 to 8 inclusive were seeded with 37 grains each of Swedish Select oats. A slight shower of rain fell before the seed was planted and the working of the moist soil caused a crust to form later over the surface soil. This may account for the apparent discrepancy in the grain yields of Nos. 4 and 5. On June 21, when the oat plants were about 2 inches high, the number of plants in each tank was reduced to 19. Each plant on an average occupied $13\frac{1}{3}$ square inches. In Swedish Select oats there are in round numbers 12,000 grains in one pound and 44 pounds in a bushel. In seeding 2 bushels per acre and deducting 10 per cent for seed that failed to grow, there would be 6 6-10 square inches for each plant, or about double the number of plants for a given area that were grown in the tanks.

In applying irrigation water to the tanks, about two-thirds of the amount was spread over the surface, the balance was run through the hose pipe to the bottom of the vessel. From May 23 to September 1, the time required to mature the crop, 20 gallons of water were added to each of the half-barrels. More should have been added in order to maintain normal temperatures in the soil within the tanks. The temperature was increased from another cause. When the irrigation water was applied, the earth in the tanks settled and exposed from two to three inches of the metal cylinder which attracted the sun.

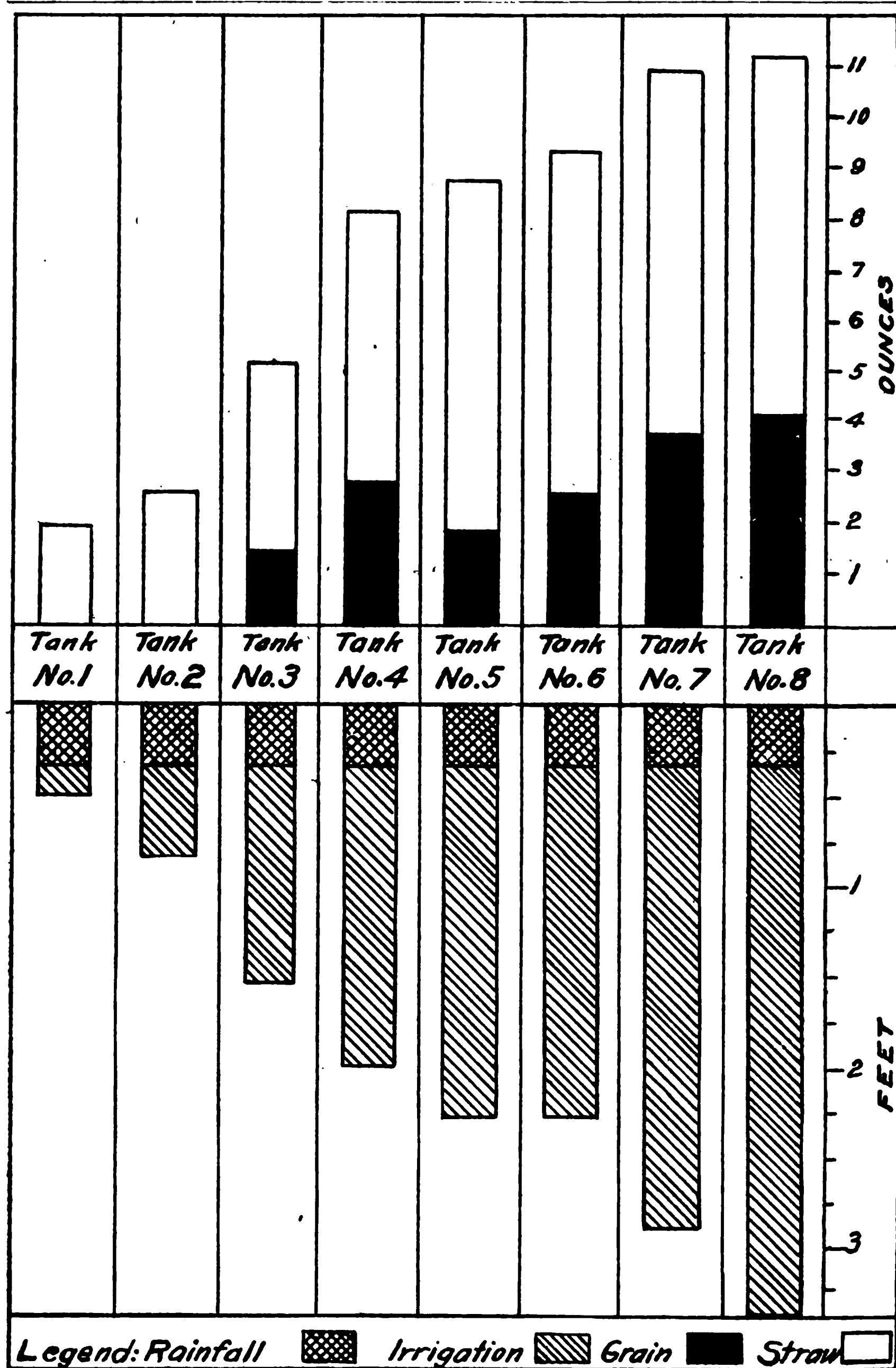


FIG. 3

In the accompanying table is given the amount of water in both irrigation and rainfall, which was applied to each tank as well as the number of pounds of water required to produce a pound of dry crop.

Number of Tank.	Irrigation Water.	Rainfall.	Total.	Tanks.
	Inches.	Inches.	Inches.	Pounds of water to produce one pound of dry matter.
1.....	2	4 ³ / ₄	6 ³ / ₄	501
2.....	6	4 ³ / ₄	10 ³ / ₄	574
3.....	14	4 ³ / ₄	18 ³ / ₄	525
4.....	20	4 ³ / ₄	24 ³ / ₄	434
5.....	22	4 ³ / ₄	26 ³ / ₄	433
6.....	22	4 ³ / ₄	26 ³ / ₄	413
7.....	32	4 ³ / ₄	36 ³ / ₄	528
8.....	38	4 ³ / ₄	42 ³ / ₄	552

The yield of both straw and grain obtained from the oats grown in the eight tanks is given in the following table. The relation between the amount of water applied and the yield is also shown in figure 3 and in Plate I.

Number of Tank.	Weight of Straw.	Weight of Grain.	Total Weight of Straw and Grain.	No. of Grains of Oats.	Rate of Increase.
	Ounces.	Ounces.	Ounces.		
1.....	1 15-16	none	1 15-16	none	0 to 1
2.....	2 11-16	none	2 11 16	none	0 to 1
3.....	3 11-16	1 7-16	5 2-16	1700	89 to 1
4.....	5 6-16	2 13-16	8 3-16	2250	118 to 1
5.....	7	1 14-16	8 14 16	1980	104 to 1
6.....	6 11-16	2 10-16	9 5-16	2450	129 to 1
7.....	7 2-16	3 14 16	11	3082	162 to 1
8.....	7	4 2-16	11 2-16	2920	154 to 1

EVAPORATION FROM SOILS.

The tanks were all weighed May 23 and again on July 8. With the exception of No. 1 each received during this period of 46 days the same amount of water. Of the 11 tanks, seven contained oat plants, three bare soil and No. 12 a small newly transplanted two-year old apple tree. The last is here classed as bare soil.

The accompanying table shows that the evaporation and transpiration from the grain was about 16 per cent. greater than the evaporation from the bare soil. For the period named, the former averages 1 1-7 inches and the latter 9-10 inches per week over the surface. For the same period the evaporation from a water surface was 13.16 inches per week.

Results of Tank Experiments from May 23 to July 8, 1902.

Number of Tank.	Weight of Soil May 23.	Weight of Irrigation Water.	Weight of Rain Water.	Total Weight.	Weight of Soil July 8.	Evaporation and Transpiration.		Difference be- tween evaporation plus transpiration and rainfall plus irrigation.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	In Weight.	In inches in depth over the surface.	
						Pounds.		Inches.
1	308.5	18.0	29.3	355.8	292.5	63.3	7.1	(—) 1.8
2	322.0	53.9	29.3	405.2	332.0	73.2	8.1	1.2
3	329.5	53.9	29.3	412.7	347.0	65.7	7.3	2.0
4	330.0	53.9	29.3	413.2	346.0	67.2	7.5	1.8
5	327.5	53.9	29.3	410.7	339.5	71.2	7.9	1.4
6	326.6	53.9	29.3	409.8	345.0	64.8	7.2	2.1
7	321.5	53.9	29.3	404.7	333.5	71.2	7.9	1.4
8	325.5	53.9	29.3	408.7	343.0	65.7	7.3	2.0
9	328.0	53.9	29.3	411.2	360.5	*50.7	*5.6	*3.7
10	319.0	53.9	29.3	402.2	344.5	*57.7	*6.4	*2.9
11	330.0	53.9	29.3	413.2	361.5	*51.7	*5.8	*3.5
12	330.5	53.9	29.3	413.7	359.5	†54.2	†6.0	†3.3

*Bare soil, evaporation only. †Small tree.

In the following table is given the results of the tank experiments during the period of growth of the oat crop. It will be noted, that the crop in every case not only evaporated all of the irrigation water but robbed the soil of part of the moisture which it contained at seed time. The minus sign indicates this loss. In the case of the tanks filled with bare soil there is a slight gain. On an average $1\frac{1}{3}$ inches when measured in depth over the surface is conserved.

Results of Tank Experiments from May 23 to September 1, 1902.

Number of Tank.	Weight of Soil May 23.	Weight of Irrigation Water.	Weight of Rain Water.	Total Weight.	Weight of soil Sept. 1.	Evaporation and Transpiration.		Difference between evaporation plus transpiration and rainfall plus irrigation.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	In Weight.	In inches in depth over the surface.	
						Pounds.		Inches.
1	308.5	18.0	42.6	369.1	260.5	108.6	12.1	(—) 5.3
2	322.0	53.9	42.6	418.5	276.0	142.5	15.9	(—) 5.1
3	329.5	125.7	42.6	497.8	281.5	216.3	24.1	(—) 5.3
4	330.0	179.6	42.6	552.2	295.0	257.2	28.6	(—) 3.8
5	327.5	197.6	42.6	567.7	284.5	283.2	31.5	(—) 4.7
6	326.6	197.6	42.6	566.8	288.0	278.8	31.0	(—) 4.2
7	321.5	287.4	42.6	651.5	285.5	366.0	40.8	(—) 4.0
8	325.5	341.3	42.6	709.4	302.5	406.9	45.3	(—) 2.5
9	328.0	89.8	42.6	460.4	343.0	*117.4	*13.1	*1.7
10	319.0	89.8	42.6	451.4	331.0	*120.4	*13.4	*1.4
11	330.0	89.8	42.6	462.4	337.0	*125.4	*14.0	*0.8
12	330.5	89.8	42.6	462.9	314.5	†148.4	†16.5	†(—)*1.7

*Bare soil, evaporation only. †Small tree.

EVAPORATION FROM STUBBLE FIELDS.

The table which follows gives the results of the experiments from the time the crop was harvested until the ground was frozen. During these three months the rainfall was 3.29 inches. No irrigation water was used. The last two columns show that there was a gain during this period in all but Nos. 11 and 12. No. 12 is easily explained by the growing tree which bore a few leaves.

The evaporation from the eight tanks containing oat stubble was 2.1 inches for September, October and November, while the evaporation from tanks holding bare soil was for the same time 3.3 inches.

This excess in the latter case may be due to the fact that the bare soil contained more moisture at the beginning of this test.

Results of Tank Experiments from September 1 to November 30, 1902.

Number of Tank.	Weight of Soil Sept. 1.	Weight of Rain Water.	Total Weight.	Weight of Soil Nov. 30,	Evaporation.		Difference be- tween evaporation and rainfall.
	Pounds.	Pounds.	Pounds.	Pounds.	In Weight.	In inches in depth over the surface.	
					Pounds.		Inches.
1.....	260.5	29.6	290.1	271.5	18.6	2.1	1.2
2.....	276.0	29.6	305.6	289.0	16.6	1.9	1.4
3.....	281.5	29.6	311.1	293.5	17.6	2.0	1.3
4.....	295.0	29.6	324.6	300.0	24.6	2.7	0.6
5.....	284.5	29.6	314.1	296.5	17.6	2.0	1.3
6.....	288.0	29.6	371.6	300.0	17.6	2.0	1.3
7.....	285.5	29.6	351.1	301.5	13.6	1.5	1.8
8.....	302.5	29.6	332.1	309.5	22.6	2.5	0.8
9.....	343.0	29.6	372.6	344.0	28.6	3.2	0.1
10.....	331.0	29.6	360.6	337.0	23.6	2.6	0.7
11.....	337.0	29.6	366.6	333.0	36.6	4.1	(—) 0.8
12.....	314.5	29.6	344.1	304.5	40.6	4.5	(—) 1.2

Nos. 1 to 8, inclusive, short stubble. Nos. 9 to 11, inclusive, bare soil. No. 12, small tree.

EVAPORATION FROM A WATER SURFACE.

In June, 1899, a wooden box was made in the form of a cube and lined with zinc. The box measured inside 3 feet in width, 3 feet in length and 3 feet in height, and when full contained one cubic yard of water. It was set in a grass plat at a considerable distance from any buildings, with its top edge but slightly raised above the surface of the ground, and filled with water to within two inches of the top. A woven wire fence 12 by 12 feet and 3 feet high, supported by light pine posts, which were painted green, inclosed the tank.

Observations were made once a week by measuring the vertical distance from the gauge on the top of the tank to the surface of the water. As the water in the tank was evaporated more was added. A thermometer was suspended within the tank, having its bulb about 6 inches below the surface. A rain gauge was also placed near the evaporation tank and the amount of rain entering the tank was also recorded. The records for July, August and September, of 1899 are in excess of those for any subsequent year. This is probably due to a slight leak in the tank. In the spring of 1900, it was relined and has since remained water tight.

In the following table are given the periods during which records were taken, the number of days, the temperature of the water and the evaporation in inches per week and per month:

1900.

	April.	May.	June.	July.	August.	Sept.	October.
Mean temperature....	73° F.	.....	.....	55° F.	46° F.
Monthly evaporation..	5.52 in.	5.99 in.	3.59 in.	3.88 in.	2.74 in.	0.98 in.
Ave. weekly evaporation.....	1.24 in.	1.39 in.	0.80 in.	0.88 in.	0.63 in.	0.22 in.

1901.

Mean temperature....	53° F.	59° F.	60° F.	68° F.	69° F.	56° F.	51° F.
Monthly evaporation*	0.89 in.	5.27 in.	4.20 in.	4.34 in.	5.27 in.	3.43 in.	2.79 in.
Ave. weekly evaporation.....	0.41 in.	1.19 in.	0.98 in.	0.98 in.	1.19 in.	0.80 in.	0.63 in.

1902.

Mean temperature....	49° F.	54° F.	67° F.	65° F.	65° F.	54° F.	50° F.
Monthly evaporation..	2.11 in.	3.40 in.	3.30 in.	4.07 in.	3.60 in.	3.01 in.	1.55 in.
Ave. weekly evaporation.....	0.49 in.	0.77 in.	0.77 in.	0.92 in.	0.81 in.	0.70 in.	0.38 in.

*From April 15 to 30.

IRRIGATION
WATER APPLIED. 2 6 14 20 22 22 32 38

INCHES.

.PLATE II.

WEIGHING A TANK.

THE AMOUNT OF WATER USED IN FIELD IRRIGATION.

For an arid state, Montana is well watered. Large rivers flow from its watersheds. Some of these have not as yet been used to any great extent for irrigation purposes. It is nevertheless true that irrigated agriculture in this state is to be measured by the water supply. Only 1 acre out of 10 or 12 acres can ever be irrigated. The supply of water when fully utilized will not suffice for more than this. One hundred years hence there will be millions of acres in Montana easy to cultivate, fertile and well located, but without water.

Until recently water for irrigation possessed a low cash value. In many parts a water right for a quarter section of land could be purchased for \$500. Owing, however, to good crops and fair prices for farm products, there has been a marked increase in the value of water rights during the past two years. The writer knows of several instances in which their value has doubled within the past year. The price of water for irrigation is regulated chiefly by the cost of conveying it, the supply available and the demand. Apart from seasonal fluctuations the supply remains fairly constant, but the other two factors are continuously increasing. In a new state like Montana it will cost much more to provide water for the second million acres than it did for the first million for the reason that the tracts adjacent to streams and easily irrigated are nearly all comprised in the latter. Every settler who conveys water to his homestead in a new district will add to the demand and produce in time a scarcity. It is, therefore, only a question of time when water for irrigation in every cultivated valley will be both scarce and costly. It is safe to predict that the water rights of the farmers which are now deemed of so small importance on some streams as to be neglected, will be worth immense sums when the present mines of this state are forgotten.

Believing that the future prosperity of this commonwealth will depend largely on the question of water for irrigation, this Station has endeavored to obtain through experiments some information as to the actual quantities being used by the irrigators. For the past four seasons these investigations have been carried on in co-operation with the Office of Experiment Stations of Washington, D. C. On behalf of the farmers and stockmen of this state,

it is a pleasure to acknowledge the help received in this connection from Director A. C. True and Professor Elwood Mead. Only a brief summary of the results obtained can be introduced here. For fuller information the reader is referred to Bulletins 86, 104 and 119 of the Office of Experiment Stations, and to Bulletin 43 of the Montana Experiment Station.

In the following table are given the amount of water used on 49 fields. The water applied is expressed in three ways, viz.: in depth over the surface irrigated, in acres per cubic foot per second and in acres per miner's inch. In order to express the duty of water in the two last ways, the length of the irrigation season must be fixed. This varies for each locality but in the table referred to an attempt has been made to give the average for each county.

1899.

Kind of Crop.	County.	Area Irrigated in Acres.	Yield Per Acre.	Length of Irrigation Season.	Rainfall in Depth Over Surface - Feet.	Amount of Water Applied		
						In Depth Over Surface - Feet	In Acres Per Cu Ft. Per Sec	In Acres Per Miner's In.
Clover . . .	Gallatin	27.44	3 tons	June 1-Aug. 31, 92 dys.	.44	1.02	179	4.4
Peas	"	4.23	31.25 bu.	"	.41	1.10	166	4.1
Grain	"	11.27	51.46 bu.	"	.42	1.98	92	2.3
Barley	"	66.39	.....	"	.41	.98	186	4.6
Oats	"	23.41	51.00 bu.	"	.38	1.53	119	3.0
Oats	"	7.26	72.75 bu.	"	.36	1.34	136	3.4
Oats	"	2.48	72.75 bu.	"	.36	2.16	84	2.1
Oats	"	25.00	.....	"	.44	1.28	143	3.6

1900.

Clover	Gallatin	66.39	.....	June 1-Aug. 31, 92 dys	.44	1.98	92	2.3
Barley	"	4.14	46.50	"	.28	1.50	122	3.1
Oats	"	25.09	.....	"	.39	.64	285	7.1
Wheat 1 Ac.	"	1.00	W-38.33 bu	"	.30	.77	237	5.6
Clover 1 Ac.	"	1.00	C-3170 lbs.	"	.30	.77	237	5.6
Oats 1 Ac. . .	"	1.00	O-75.58 bu.	"	.30	.77	237	5.6
Peas 1 Ac. . .	"	1.00	P-1330 lbs.	"	.39	.56	326	8.2
Barley	"	1.00	87.29 bu.	"	.28	1.17	156	3.9
Oats	"	8.51	74.67 bu.	"	.40	1.39	131	3.3
Barley	"	4.52	68.59 bu.	"	.42	1.96	93	2.3
Clover	"	7.26	.....	"	.44	2.70	67	1.7
Clover	"	35.90	.....	"	.44	1.79	102	2.5
Alfalfa	Yellowstone	53.40	5.17 tons	May 18-Sep. 30, 135 dys.	.44	1.30	206	5.1
Orchard	Ravalli	40.00	.....	Apr. 25-Aug. 31, 128 dys.	.13	1.46	174	4.3
Oats	"	161.70	33.00 bu.	"	.13	1.30	195	4.9
Oats	"	102.20	34.00 bu.	"	.13	6.06	42	1.0

1901.

Kind of Crop.	County.	Area Irrigated in Acres.	Yield Per Acre	Length of Irrigation Season.	Depth Feet.	Amount of Water Applied	
						In Acres Per Cu Ft Per Sec	In Acres Per Miner's In.
Clover	Gallatin	20.86	3.36 tons	June 1-Aug. 31, 92 dys.	.65	.92 198	4.9
Clover	"	5.59	3.36 tons	"	.67	1.81 101	2.5
Clover	"	7.13	3.36 tons	"	.62	1.24 147	3.7
Clover	"	6.85	3.36 tons	"	.62	1.55 118	2.9
Wheat ..	"	5.25	46.20 bu.	"	.45	1.20 152	3.8
Wheat 1 Ac.	"	1.00	W 42.90 bu.	"	.43	.77 237	5.9
Barley 1 Ac.	"	1.00	B-61.50 bu.	"	.43	.77 237	5.9
Clover 1 Ac.	"	1.00	C-1.59 tons	"	.43	.77 237	5.9
Sugar Beets	"	1.00	10 tons	"	.59	1.46 125	3.1
Oats.....	"	15.33	73 bu.	"	.43	1.63 112	2.3
Clover	"	27.84	3 tons	"	.62	.95 192	4.8
Barley	"	12.47	59 bu.	"	.46	.85 215	5.4
Peas.....	"	8.41	37.5 bu.	"	.77	.35 521	13.0
Oats.....	"	37.30	.....	"	.45	1.27 144	3.6
Orchard ...	Ravalli	40.00	.....	Apr. 25-Aug. 31, 128 dys.	.40	1.56 163	4.1
Clover	"	161.70	.9 tons	"	.49	1.50 169	4.2
Clover	"	102.00	1 ton	"	.45	2.22 114	2.8

1902.

Barley	Gallatin	19.80	67 bu.	June 1-Aug. 31, 92 dys.	.64	.97 189	4.7
Rotation Plots	"	6.00	31 bu.	"	.64	1.07 171	4.3
Wheat.....	"	5.62	.....	"	.72	2.44 75	1.9
Oats.....	"	3.38	.....	"	.54	1.27 144	3.6
Clover	"	9.72	.....	"	.78	1.66 110	2.7
Oats.....	"	8.93	.....	"	.54	1.77 103	2.6
Alfalfa	"	4.02	.....	"	.78	1.01 181	4.5
Clover	"	27.84	.....	"	.78	1.78 103	2.6
Clover	"	81.30	.....	"	.78	3.13 58	1.5
Orchard ...	Ravalli	40.00	.....	Apr. 25-Aug. 31, 128 dys.	.66	1.77 143	3.6
Clover	"	161.00	.....	"	.66	1.30 195	4.8
Clover	"	102.00	.....	"	.66	3.95 55	1.3

THE AMOUNT OF WATER USED UNDER CANALS.

In comparing the amounts of water used on fields as given in the preceding table with those under canals in the table which follows, it will be seen that the latter are much larger for similar areas. This difference in duty arises from the various losses which occur in conveying water through a ditch or canal from the source of supply to the place of use. Notwithstanding these heavy losses which vary from 20 to 35 per cent of the total flow in the main channels alone, the average duty of water over the 87,240 acres represented in the accompanying table is 2.23 acres for each miner's inch diverted, or at the rate of 0.45 of a miner's inch per acre.

Year.	Canal.	County.	Area Irrig- ated.	Water Used.	Water Applied.		
			Acres.	Acre- Feet	In Depth Over Surface—Feet.	In Acres Per Cu Ft Per Sec.	In Acres Per Miner's In.
1901	Big Ditch.....	Yellowstone	18144	46507	2.56	85	2.13
1902	Big Ditch.....	"	20038	73165	3.65	76	1.90
1901	Republican.....	Ravalli	4105	13758	3.35	81	2.02
1902	Republican.....	"	4850	17856	3.68	89	2.22
1901	Hedge.....	"	5260	20883	3.97	65	1.64
1902	Hedge.....	"	5420	31274	5.76	58	1.46
1901	Ward.....	"	3587	8626	2.41	112	2.81
1902	Ward.....	"	3985	9933	2.49	132	3.30
1901	Skalkaho.....	"	1600	7494	4.68	56	1.40
1902	Skalkaho.....	"	1975	13423	6.79	48	1.21
1901	Gird.....	"	1211	1759	1.45	102	2.56
1902	Gird.....	"	1345	4710	3.50	81	2.04
1899	Middle Creek.....	Gallatin	3853	8074	2.10	87	2.19
1900	Middle Creek.....	"	3853	7324	1.90	110	2.75
1901	Middle Creek.....	"	3186	7454	2.34	90	2.26
1902	Middle Creek.....	"	4828	5577	1.15	151	3.78

DISCHARGE OF THE PRINCIPAL RIVERS OF MONTANA.

J. S. BAKER, Resident Hydrographer.

For several years the irrigation department of the Station has supervised and conducted the hydrographic work of the U. S. Geological Survey in Montana. Gaging stations are established and maintained at favorable locations on the principal rivers of the state and measurements made of the flow at each station from four to twelve times during each year. An observer residing near the gaging station observes and records the height of water at least once a day. These records are mailed to the Experiment Station and are forwarded from thence to Washington, D. C. The data obtained from a number of stream measurements, together with the daily records of the observer, enable the engineer to compute with reasonable accuracy the daily flow, or discharge, throughout the year. The records for the years 1901 and 1902 have been thus computed and are herein given for the following rivers and streams: Missoula River, Bitter Root River, Madison River, Jefferson River, Gallatin River, West Gallatin River, Middle Creek, Yellowstone River, Marias River, Milk River, and St. Mary river. Also discharge measurements were made on the Milk river, Swift Current creek, Missouri river, St. Mary river, Two Medicine river and Crow creek, but no gage-height observations were made. It should be observed that when ice forms on the surface of a stream neither the gage heights nor the flow can be accurately determined. In the accompanying tables the discharges are given in cubic feet per second. Since 40 Montana miner's inches are equivalent to one cubic foot per second, the flow may be converted into miner's inches by multiplying the figures given by the number 40.

Daily Discharge in Second-feet of Missoula River, at Missoula, Mont., for 1901.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7300	13960	4650	1625	970	1469	1495	1365
2	10120	12475	4525	1625	970	1495	1495	1430
3	12610	11720	4150	1625	1025	1469	1495	1469
4	16100	11520	4150	1625	1168	1495	1469	1534
5	16975	11320	3900	1625	1430	1495	1534	1469
6	15950	10000	3600	1599	1469	1430	1625	1430
7	14950	8700	3500	1534	1430	1430	1599	1339
8	14450	7930	3540	1495	1469	1430	1560	1190
9	14450	7475	3360	1495	1469	1430	1534	1339
10	13450	6880	3440	1430	1430	1534	1534	1430
11	13100	6950	3260	1430	1469	1469	1495	a
12	12475	7125	3015	1339	1534	1430	1495	a
13	13450	7230	2879	1300	1495	1430	1495	a
14	14950	6880	2845	1278	1469	1430	1469	a
15	16350	6450	2811	1223	1495	1430	1430	a
16	16975	6150	2727	1223	1430	1430	1365	a
17	19000	5940	2644	1190	1430	1430	1365	a
18	20200	5610	2512	1190	1430	1430	1430	a
19	19780	5500	2314	1190	1469	1430	1430	a
20	18400	6000	2182	1168	1430	1430	1404	a
21	16600	6300	2100	1135	1365	1430	1404	a
22	15450	6000	2100	1135	1404	1430	1404	a
23	15200	5850	2072	1135	1404	1495	1469	a
24	14600	5790	2002	1113	1404	1430	1495	a
25	13200	5610	1932	1135	1430	1339	1469	a
26	13450	5640	1890	1113	1430	1430	1469	a
27	13950	5790	1890	1025	1534	1534	1430	a
28	4400	15700	5760	1794	1025	1560	1404	1404	a
29	4400	16975	5275	1755	1025	1560	1469	1365	a
30	5275	17980	5100	1755	1003	1560	1534	1365	a
31	16100	.....	1690	970	.....	1599	.....	a

Daily Discharge in Second-feet of Missoula River, at Missoula, Mont., for 1902.

1	a	a	1847	1715	2754	15945	5056	2637	1865	1865	1820	1715
2	a	a	1804	1702	2870	14830	5167	2544	1847	1780	1847	1715
3	a	a	1750	1736	2916	13957	6365	2416	1865	1780	1780	1650
4	a	a	1736	1847	2947	13150	6446	2380	1804	1804	1780	1682
5	a	a	1768	2320	2870	11940	6500	2320	1768	1980	1804	a
6	a	a	1780	2267	2754	10400	6975	2299	1847	1847	1780	a
7	a	a	1780	2479	3008	9617	6692	2215	1736	1768	1804	a
8	a	a	1847	2837	3670	9200	6188	2195	1780	1768	1924	a
9	a	a	1820	2870	4542	8825	5978	2145	1768	1780	2025	a
10	a	a	1886	2479	6127	11090	5670	2267	1768	1804	2097	2097
11	a	a	1886	2215	7159	11393	5550	2070	1715	1820	2246	1980
12	a	a	1865	2052	8404	11000	5437	2070	1736	1865	2115	1940
13	a	a	1865	2052	8150	10100	5280	2052	1750	1820	2070	1886
14	a	a	1847	1980	9580	9469	4942	2070	1715	1804	2070	1865
15	a	a	1768	1980	12412	9250	4762	2215	1736	1820	2025	1847
16	a	a	1669	2025	15183	8875	4542	2165	1750	1780	2025	a

a Ice.

Daily Discharge of Missoula River, for 1902, Continued.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	1456	a	1750	2145	14830	8543	4435	2097	1780	1820	1940	a
18	a	a	1750	2505	14120	7278	4762	2246	1750	1847	1940	a
19	a	a	1750	2754	12795	6810	4875	2215	1780	1780	1964	a
20	a	a	1736	2916	12200	6446	4542	2215	1804	1780	1900	a
21	a	a	1736	3008	12712	6188	4327	2097	1924	1780	1865	a
22	a	a	1750	2870	13795	5907	4073	2070	1780	1780	1780	a
23	a	a	1636	2610	14211	5978	3910	2025	1780	1780	1715	a
24	a	a	1601	2570	14211	6127	3670	2025	1804	1804	1736	a
25	a	a	1650	2570	14211	6086	3517	2052	1750	1847	1715	a
26	a	1980	1750	2544	14211	5978	3388	1980	1780	1847	1715	a
27	a	1980	1820	2637	15255	5978	3197	1940	1847	1820	1682	a
28	a	1964	1780	2610	16230	5622	3099	1940	1804	1820	1650	3240
29	a	.....	1715	2356	17805	5437	2947	1900	1780	1820	a	3240
30	a	.....	1601	2440	17952	5212	2916	1865	1924	1780	1780	3240
31	a	.....	1615	.....	16440	.....	2787	1865	.....	1780	.....	3240

Daily Discharge in Second-feet of Big Blackfoot River, at Bonner, Mont., for 1901.

1	.....	.....	.....	.....	3890	7417	.....	.....	.....	.....	.....	.....
2	.....	.....	.....	.....	5620	6905	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	7931	6391	.....	.....	.....	.....	.....	.....
4	.....	.....	.....	.....	8909	5877	.....	.....	.....	.....	.....	.....
5	.....	.....	.....	.....	9475	5234	.....	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	8961	4720	.....	.....	.....	.....	.....	.....
7	.....	.....	.....	.....	9346	4070	.....	.....	.....	.....	.....	.....
8	.....	.....	.....	.....	8961	4070	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	.....	8318	3537	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	8318	3537	.....	.....	.....	.....	.....	.....
11	.....	.....	.....	.....	7289	3275	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	.....	7162	3275	.....	.....	.....	.....	.....	.....
13	.....	.....	.....	.....	7931	3275	.....	.....	.....	.....	.....	.....
14	.....	.....	.....	.....	8575	3100	.....	.....	.....	.....	.....	.....
15	.....	.....	.....	.....	8575	2950	.....	.....	.....	.....	.....	.....
16	.....	.....	.....	.....	9604	2950	.....	.....	.....	.....	.....	.....
17	.....	.....	.....	.....	11531	2950	.....	.....	.....	.....	.....	.....
18	.....	.....	.....	.....	11402	2800	.....	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	11017	3025	.....	.....	.....	.....	.....	.....
20	.....	.....	.....	.....	10503	3100	.....	.....	.....	.....	.....	.....
21	.....	.....	.....	.....	9475	3100	.....	.....	.....	.....	.....	.....
22	.....	.....	.....	.....	8961	3100	.....	.....	.....	.....	.....	.....
23	.....	.....	.....	.....	8062	3025	.....	.....	.....	.....	.....	.....
24	.....	.....	.....	.....	7800	3100	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	.....	7545	2800	.....	.....	.....	.....	.....	.....
26	.....	.....	.....	.....	7672	2800	.....	.....	.....	.....	.....	.....
27	.....	.....	.....	.....	8062	2800	.....	.....	.....	.....	.....	.....
28	.....	.....	.....	.....	8961	2650	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	.....	9860	2650	.....	.....	.....	.....	.....	.....
30	.....	.....	.....	.....	9604	2650	.....	.....	.....	.....	.....	.....
31	.....	.....	.....	.....	8447	.....	.....	.....	.....	.....	.....	.....

a Ice.

Daily Discharge in Second-feet of Bitter Root River, at Grantsdale, Mont., for 1902.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1020	7790	2650	790	205	205	280	395
2	1150	7325	2450	790	175	205	...	395
3	1020	5900	3050	700	175	205	...	395
4	900	5665	3050	700	175	240	...	395
5	900	5220	3700	615	150	240	...	395
6	1020	4790	3255	615	150	240	...	340
7	1430	4790	3050	530	135	240	...	395
8	2265	5220	2650	530	135	280	...	395
9	3700	7100	2265	460	135	280	395	395
10	5005	9270	2450	460	150	280	395	530
11	5440	7555	2650	460	150	280	395	530
12	5900	6855	2850	460	135	280	395	460
13	6380	6380	2650	395	135	240	340	460
14	7790	5900	2450	395	135	205	340	395
15	8970	5220	2265	395	135	205	340	460
16	8340	4790	2265	395	150	205	340	530
17	6855	4355	2085	395	150	205	340	395
18	5665	4575	2085	395	175	240	340	395
19	4790	3700	1910	395	150	240	340	395
20	3920	3700	1745	395	175	240	340	530
21	3470	3700	1745	340	175	240	340	530
22	3255	3920	1745	340	175	280	340	530
23	3255	4790	1585	340	175	280	530	530
24	3700	5005	1585	280	205	240	615	530
25	1020	4140	4355	1430	280	205	240	280	615
26	1150	4790	3920	1430	280	205	240	280	1150*
27	1150	7100	3700	1290	240	205	240	280	460
28	1150	8970	3470	1150	240	205	240	280	460
29	1020	1175	3255	1020	240	205	240	340	460
30	1020	8970	3050	1020	205	175	240	340	395
31	8340	....	900	205	...	280	...	395

Daily Discharge in Second-feet of Madison River, near Norris, Mont., for 1901.

1	.....	.....	.....	1900	2831	5400	2400	1794	1475	1475	1475	1475
2	.....	.....	.....	1900	2975	5244	2400	1688	1475	1475	1475	1475
3	.....	.....	.....	1900	4025	5088	2400	1688	1475	1475	1475	1475
4	.....	.....	.....	1900	4625	4475	2400	1581	1475	1475	1475	1475
5	.....	.....	.....	1900	4415	4475	2400	1581	1475	1475	1475	1475
6	.....	.....	.....	1900	3725	4325	2400	1900	1475	1475	1475	1475
7	.....	.....	.....	1900	2975	3875	2400	1688	1475	1475	1475	1475
8	.....	.....	.....	1900	2975	3275	2400	1475	1475	1475	1475	1475
9	.....	.....	.....	1900	2975	3275	2400	1794	1475	1475	1475	1475
10	.....	.....	.....	1900	2975	2975	2400	1794	1475	1475	1475	1475
11	.....	.....	.....	1900	2975	2975	1900	1581	1475	1475	1475	1475
12	.....	.....	.....	1900	3425	2975	1900	1581	1475	1475	1475	1475
13	.....	.....	.....	1900	4175	3275	1900	1581	1475	1475	1475	1475
14	.....	.....	.....	1900	4775	3275	1900	1581	1475	1475	1475	1475
15	.....	.....	.....	1900	5562	2975	1900	1581	1475	1475	1475	a
16	.....	.....	.....	1900	6050	2975	1900	1581	1475	1475	1475	a

*Ice gorge formed on Dec. 26, went out on Dec. 27. a Ice.

Daily Discharge of Madison River, for 1901, Continued.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	1900	6212	2975	1900	1581	1475	1475	1475	a
18	1900	8000	2975	1900	1475	1475	1475	1475	a
19	1900	8162	2975	1900	1475	1475	1475	1475	a
20	1900	8000	2975	1900	1475	1475	1475	1475	a
21	1900	7188	2975	1900	1475	1475	1475	1475	a
22	1900	7025	3275	1900	1475	1475	1475	1475	a
23	1900	6212	2975	1900	1475	1475	1475	1475	a
24	2025	5888	2975	1900	1475	1475	1475	1688	a
25	2150	5244	2688	1688	1475	1475	1475	1688	a
26	2150	5088	2688	1688	1475	1475	1475	1688	a
27	2150	5562	2588	1688	1475	1475	1475	1688	a
28	2150	6212	2688	1794	1475	1475	1475	1688	a
29	2150	6375	2688	1688	1475	1475	1475	1688	a
30	2275	6050	2400	1688	1475	1475	1475	1688	a
31	1900	.....	5400	.....	1688	1475	.....	1475	.....	a

Daily Discharge in Second-feet of Madison River, near Norris, Mont., for 1902.

1	a	a	a	910	1570	6140	3020	1570	1360	1360	1360	a
2	a	a	.....	910	1570	6140	3160	1570	1360	1360	1360	a
3	a	a	a	1175	1570	5385	3160	1570	1360	1360	1360	a
4	a	.....	.....	1175	1570	4730	3450	1460	1360	1360	1360	a
5	a	.....	.....	1260	1570	4655	3160	1360	1360	1360	1360	a
6	a	.....	.....	1360	1636	4495	3160	1360	1360	1360	1360	a
7	a	.....	.....	1360	1680	4195	3020	1360	1360	1360	1360	a
8	a	.....	.....	1360	1815	4195	2880	1360	1360	1360	1360	a
9	a	.....	.....	1360	1815	4780	2600	1360	1360	1360	a	a
10	a	a	a	1360	1815	5690	2600	1360	1360	1360	a	a
11	a	.....	.....	1360	2075	5990	2600	1360	1360	1360	a	a
12	a	.....	.....	1360	2325	5990	2600	1360	1360	1360	a	a
13	a	.....	.....	1360	2600	5840	2600	1360	1360	1360	a	a
14	a	.....	.....	1360	2880	5840	2600	1360	1360	1360	a	a
15	a	.....	.....	1360	3300	5540	2600	1360	1360	1360	a	a
16	a	.....	.....	1360	3745	4935	2600	1360	1360	1360	a	a
17	a	.....	a	1360	3745	4195	2475	1360	1360	1360	a	a
18	a	.....	.....	1460	3745	3885	2325	1360	1360	1360	a	a
19	a	.....	.....	1460	3687	3450	2325	1360	1360	1360	a	a
20	a	a	.....	1570	3450	3745	2325	1360	1360	1360	a	a
21	a	.....	.....	1570	4730	2880	2325	1360	1360	1360	a	a
22	a	.....	.....	1570	2880	2880	2075	1360	1360	1360	a	a
23	a	.....	910	1570	2880	3020	1945	1360	1360	1360	a	a
24	a	.....	910	1570	2964	3160	1815	1175	1360	1360	a	a
25	a	.....	910	1815	3160	3160	1815	1175	1360	1360	a	a
26	a	.....	910	1815	3600	3450	1815	1175	1360	1360	a	a
27	a	.....	910	1815	4345	3160	1815	1175	1360	1360	a	a
28	a	.....	910	1815	4935	2880	1815	1175	1360	1360	a	a
29	a	.....	910	1815	5230	2880	1680	1175	1360	1360	a	a
30	a	.....	910	1570	5690	2880	1570	1175	1360	1360	a	a
31	a	.....	910	.....	6140	.....	1570	1360	.....	1360	.....	a

a Ice.

Daily Discharge in Second-feet of Jefferson River, at Sappington, Mont., for 1901.												
Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	a	a	a	1265	5840	7580	2375	615	490	820	975	1065
2	a	a	a	1265	5950	6748	2290	615	490	820	975	1065
3	a	a	a	1265	6170	6060	2120	615	430	820	975	1065
4	a	a	a	1265	6400	5408	1871	615	490	820	976	1065
5	a	a	a	1265	6400	5090	1792	615	550	820	1020	1065
6	a	a	a	1265	6170	4780	1792	615	550	820	1020	1065
7	a	a	a	1265	6170	4280	1635	615	550	820	1020	1065
8	a	a	1635	1265	5950	3900	1635	615	615	820	1065	1065
9	a	a	1635	1375	5730	3618	1505	615	648	820	1065	1065
10	a	a	1635	1375	5730	3525	1505	615	680	820	1065	1065
11	a	a	1635	1375	5730	3250	1375	615	680	820	1065	1065
12	a	a	1635	1505	5840	3250	1265	550	680	820	1065	1065
13	a	a	1635	1505	5950	3525	1155	550	680	820	1065	1155
14	a	a	1505	1505	6285	3525	1155	550	680	820	1065	1155
15	a	a	1505	1505	6630	3525	1065	550	667	820	1065	1155
16	a	a	1505	1635	7220	3525	975	550	648	820	1065	1155
17	a	a	1505	1635	7704	3340	975	550	648	820	1065	1265
18	a	a	1505	1792	8575	3160	897	550	648	820	1065	a
19	a	a	1375	1950	9200	3160	897	550	680	820	1065	a
20	a	a	1375	2120	9325	2892	820	550	680	820	1065	a
21	a	a	1375	2460	8825	2630	820	550	680	859	1065	2460
22	a	a	1375	2630	8575	2375	750	550	715	859	1065	....
23	a	a	1375	3070	8075	2290	750	550	750	859	1065	....
24	a	a	1375	3800	7340	2630	715	550	771	897	1065	....
25	a	a	1375	4090	6630	2805	680	550	785	897	1065	....
26	a	a	1375	4285	6515	3160	680	550	785	897	1155	....
27	a	a	1375	4285	6630	3250	680	550	820	897	1155	....
28	a	a	1265	4187	6748	3340	680	550	820	897	1155	2805
29	a	.....	1265	4780	7704	3160	680	550	820	936	1155	....
30	a	.....	1265	5515	7828	2892	680	550	820	936	1065	....
31	a	.....	1265	....	7704	....	615	550	..	936	....	....

Daily Discharge in Second-feet of Jefferson River, at Sappington, Mont., for 1902.												
1	.....	2870	.....	875	2870	9105	2870	1272	685	875	1210	610
2	.....	a	.....	927	2870	9105	2870	1090	640	875	1210	610
3	.....	a	.....	1090	2870	8705	2870	1090	510	875	1210	610
4	3375	a	.....	1090	2870	7905	3462	980	640	875	1272	1755
5	.....	a	.....	1210	2710	6817	4090	875	685	927	1335	1755
6	.....	a	.....	1335	2550	6335	4640	875	685	980	1335	1755
7	.....	a	.....	1210	2390	5555	4450	550	730	980	1335	1755
8	.....	3040	.....	1335	2390	5272	3997	470	775	980	1335	1755
9	.....	a	.....	1210	2955	5365	3550	550	775	980	1335	1755
10	.....	a	.....	1335	3462	5365	3462	685	775	980	1335	1755
11	2870	a	.....	1335	3997	5555	3040	595	730	980	1402	1755
12	.....	a	.....	1210	4360	6335	2955	595	685	980	1470	1755
13	.....	a	.....	1090	4450	6335	2790	730	685	1090	1470	1755
14	.....	a	.....	1335	4815	6335	2550	775	685	1090	1540	1755
15	.....	3205	.....	980	5460	6335	2470	775	685	1090	1610	1755
16	.....	a	.....	1090	6525	6040	2150	775	685	1090	1610	1610

a Ice.

Daily Discharge of Jefferson River, for 1902, Continued.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	.....	a	.....	1210	7110	5555	2070	775	685	1090	1610	1470
18	a	a	.....	1210	6915	4450	1992	875	730	1090	1610	1470
19	a	a	.....	1335	6335	3905	1992	875	775	1090	1755	1470
20	a	a	.....	1610	6140	3462	2230	980	775	1090	1755	1470
21	a	a	.....	2870	6140	3290	2070	927	775	1090	1682	1470
22	a	3205	.....	3462	5750	3040	1992	875	775	1090	1610	1470
23	a	a	.....	3550	5365	2870	1835	825	775	1090	1470	1470
24	a	.....	.....	3550	5652	2870	1755	775	775	1090	1470	1470
25	3205	.....	.....	3550	5750	2870	1610	775	775	1150	1470	1610
26	a	.....	.....	3122	5750	2790	1540	775	775	1210	1470	1610
27	a	.....	.....	3040	5845	2710	1335	775	825	1210	1470	1610
28	a	.....	.....	3040	6450	2710	1335	775	875	1210	1470	1610
29	a	.....	.....	3040	7305	2710	1335	775	875	1210	1470	1610
30	a	.....	1090	2870	8605	2870	1210	685	875	1210	1470	1610
31	a	.....	980	.....	9305	.....	1210	685	...	1210	.....	1610

Daily Discharge in Second-feet of Gallatin River, at Logan, Mont., for 1902.

1	a	a	560	710	.....	4430	*	450	400	590	590	780
2	a	a	560	710	.....	4275	*	423	400	590	590	650
3	a	a	560	710	.....	3450	*	400	400	590	590	650
4	a	a	560	710	710	3165	*	400	400	590	590	710
5	530	a	560	710	650	2765	*	400	400	590	590	780
6	530	a	560	710	650	2895	*	382	400	590	650	710
7	530	a	560	710	710	2895	*	382	400	590	590	710
8	530	a	554	710	780	4050	*	382	400	590	650	710
9	530	a	780	710	940	3970	*	382	400	590	650	650
10	530	a	780	710	940	4275	*	400	400	590	650	650
11	530	a	780	710	1120	4430	*	400	400	590	710	650
12	530	a	710	710	1735	4050	*	400	400	590	780	590
13	530	a	710	.....	1910	4350	*	400	t	590	710	530
14	530	a	710	.....	1965	4430	1025	400	t	590	650	650
15	530	a	710	.....	2895	2380	860	423	t	590	650	780
16	530	590	710	.....	3025	1910	780	423	t	590	650	940
17	530	590	710	.....	3090	1850	710	423	t	590	650	1850
18	a	590	710	.....	3090	1790	710	450	t	590	650	1790
19	a	590	710	.....	2960	1850	710	450	t	590	710	2260
20	a	590	710	.....	2960	1630	650	423	t	590	650	2320
21	a	590	710	.....	2895	1415	590	423	t	590	590	2570
22	a	590	710	.....	2830	1630	590	423	t	590	650	2960
23	a	560	710	.....	2895	1735	530	423	t	590	710	3240
24	a	560	710	.....	2830	1735	480	423	t	590	780	2895
25	a	560	710	.....	2570	1630	450	400	t	590	780	2830
26	a	560	710	.....	2570	1735	450	423	t	590	780	2830
27	a	560	710	.....	3025	1415	450	400	t	590	780	2960
28	a	560	710	.....	3520	1520	480	400	590	590	780	1415
29	a	...	710	.....	3670	*	450	400	590	590	780	1415
30	a	...	710	.....	3895	*	450	400	590	590	780	1965
31	a	...	710	.....	4350	*	423	400	.....	590	...	2200

a Ice. * No record. t Record unreliable. ‡ Ice going out caused fall in river.

Daily Discharge in Second-feet of West Gallatin River, at Salesville, Mont., for 1902.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	400	400	360	360	500	5000	1530	810	500	450	450	450
2	400	400	360	360	500	3220	1665	755	475	450	450	450
3	400	450	360	360	450	2775	1737	700	450	450	450	450
4	400	500	360	360	450	2605	1530	700	450	450	450	450
5	400	625	360	360	450	2605	1415	700	400	450	450	450
6	400	650	360	360	500	2605	1415	650	400	450	450	450
7	400	650	360	360	600	3130	1310	650	400	450	450	450
8	400	600	360	360	650	4887	1263	650	360	450	450	450
9	400	600	360	360	810	5225	1215	650	360	450	450	360
10	400	600	360	360	982	5000	1215	600	360	450	450	360
11	400	500	360	360	1060	5000	1215	600	360	450	450	360
12	400	500	360	360	1175	4325	1215	550	360	450	450	360
13	400	500	360	400	1472	4325	1263	600	360	450	450	360
14	400	450	360	400	1885	4213	1263	600	360	450	450	360
15	400	400	360	360	2690	3595	1310	600	450	450	450	360
16	400	400	360	360	2120	2605	1310	600	400	450	450	360
17	400	400	360	360	1885	2445	1310	600	400	450	450	330
18	400	360	360	360	1597	2445	930	550	450	450	450	315
19	360	360	360	360	1415	2285	1135	550	450	450	450	400
20	360	360	360	500	1175	1960	1135	550	450	450	450	400
21	360	360	360	500	1028	1960	995	550	450	450	450	450
22	360	360	360	450	1060	2040	995	550	400	450	450	450
23	360	360	360	450	1215	2285	995	550	450	450	450	450
24	360	360	392	450	1472	2365	995	500	450	450	450	450
25	360	360	380	450	1472	2285	995	500	450	450	400	450
26	360	360	392	450	1960	2445	995	500	450	450	360	450
27	360	360	372	450	2525	2120	995	500	450	450	330	450
28	400	360	380	450	3997	1960	995	500	450	450	360	450
29	400	...	380	450	4663	1530	870	500	450	450	450	450
30	400	...	360	450	5338	1530	870	500	450	450	450	360
31	400	...	360	...	5565	....	870	500	...	450	...	360

Daily Discharge in Second-feet of West Gallatin River, at Salesville, Mont., for 1901.

1	455	455	455	475	1230	4125	1440	562	475	495	475	455
2	475	455	455	455	1580	3945	1160	625	495	495	475	455
3	475	455	455	455	2545	3425	1160	625	495	495	475	455
4	495	455	465	455	2075	2940	1160	590	475	495	475	455
5	515	455	435	455	1790	2780	1160	562	495	495	475	455
6	505	465	441	475	1650	2540	1037	535	495	495	475	455
7	525	461	455	475	1580	2380	1037	535	495	495	475	455
8	535	455	435	475	1930	2780	1037	535	495	495	475	455
9	563	455	435	455	1930	2780	915	535	495	495	475	455
10	515	455	455	475	2150	2005	915	535	495	495	475	455
11	515	455	435	475	2225	1860	915	535	495	495	475	455
12	515	495	435	475	2540	1720	915	535	495	495	475	455
13	515	495	435	475	3100	1650	832	535	495	495	475	455
14	515	495	435	475	3180	1650	832	525	495	495	475	465
15	535	495	435	481	4412	1720	750	495	495	495	475	475
16	535	495	435	475	5058	1580	705	495	495	495	475	475

Daily Discharge of West Gallatin River, for 1901, Continued.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	515	455	435	475	6332	1650	705	515	495	475	475	455
18	525	455	441	475	7910	1580	660	515	495	475	475	455
19	525	455	441	495	6475	1650	660	515	495	475	475	455
20	515	455	455	728	6475	1790	590	535	495	475	455	455
21	600	455	455	750	4945	1860	590	535	495	475	435	455
22	535	455	455	750	3940	2300	590	515	495	475	435	455
23	495	455	455	750	3260	2300	590	515	495	475	435	455
24	475	475	465	625	3425	2300	590	515	495	475	435	455
25	475	475	475	660	3677	2300	590	495	495	475	435	455
26	475	475	475	625	4618	2150	590	495	495	475	455	455
27	475	461	473	563	4618	1860	590	495	495	475	475	455
28	475	465	473	563	5415	1720	535	495	495	475	455	455
29	475	...	473	660	4412	1580	535	495	495	475	455	455
30	455	...	473	750	4310	1440	535	495	495	475	475	455
31	455	...	455	...	4310	....	515	495	...	475	...	455

Daily Discharge in Second-feet of Middle Creek, at Bozeman, Mont., for 1902.

1	...	...	...	...	...	...	181	72	53	51	...	...
2	...	...	...	...	...	226	181	72	53	51	...	...
3	...	...	...	...	...	181	181	..	51	51	...	...
4	...	...	...	...	...	136	158	72	51	...	...	...
5	...	...	...	...	...	136	158	69	51	...	...	...
6	...	...	...	...	...	136	...	66	49	...	...	...
7	...	...	...	...	...	181	136	66	..	...	...	...
8	...	...	...	...	...	...	122	66	49	...	...	...
9	...	...	...	...	...	226	122	60	49	...	...	...
10	...	...	...	...	...	316	122	..	49	...	...	...
11	...	...	...	...	...	361	122	60	49	...	...	...
12	...	...	...	...	...	316	122	60	49	...	...	...
13	...	...	...	...	...	271	...	60	49	...	...	...
14	...	...	...	...	...	316	107	60	..	...	...	...
15	...	...	...	...	226	...	107	60	49	...	...	...
16	...	...	...	...	181	271	122	60	49	...	...	...
17	...	...	...	...	181	226	122	60	49	...	...	...
18	...	...	...	...	136	181	107	60	49	...	...	...
19	...	...	...	...	136	181	97	53	49	...	...	...
20	...	...	...	...	107	158	..	53	49	...	...	...
21	...	...	...	...	107	181	97	53	..	...	...	...
22	...	...	...	...	107	...	97	53	49	...	...	...
23	...	...	...	...	107	226	97	53	49	...	...	...
24	...	...	...	...	136	226	97	..	49	...	...	...
25	...	...	...	...	136	249	97	53	51	...	...	...
26	...	...	...	...	181	226	88	53	51	...	...	...
27	...	...	...	...	226	226	..	53	51	...	...	...
28	...	...	...	...	271	181	80	53	..	...	...	...
29	...	...	...	...	271	...	72	53	51	...	...	...
30	...	...	...	...	271	181	72	53	51	...	...	...
31	...	...	...	...	316	...	72	..	..	...	...	...

Daily Discharge in Second-feet of Yellowstone River, at Livingston, Mont., for 1901.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	1316	1316	2667	13250	7920	3520	2440	2050	1750	1473
2	a	.....	1369	1316	4166	13250	7610	3820	2380	2050	1750	....
3	a	.....	1240	1316	5052	12725	8075	4400	2440	2050	1700	....
4	a	1085	1110	1343	5860	12200	7610	3820	2560	2050	1700	....
5	a	.....	1163	1343	4941	11700	7455	3660	2560	2050	1700	....
6	.....	.....	1265	1343	4732	10775	7320	3520	2500	2050	1700	1380
7	.....	.....	1316	1369	5052	10775	6765	3380	2440	2050	1700	....
8	.....	.....	1316	1369	5740	10775	6645	3380	2380	2000	1655	....
9	.....	.....	1316	1343	5980	9950	6500	3480	2380	2000	1655	1286
10	a	.....	1316	1369	6475	9950	6250	3380	2320	2000	1610	....
11	.....	1085	1290	1369	7270	9550	6250	3240	2210	2050	1610	....
12	.....	.....	1265	1395	8470	9550	6550	3100	2210	2050	1610	....
13	a	.....	1316	1462	....	9200	6000	3030	2210	2000	1610	....
14	1265	.....	1316	1462	9500	8850	5750	2960	2210	2000	1565	....
15	.....	.....	1316	1395	10800	8540	5500	2960	2210	2000	1565	....
16	.....	.....	1316	1420	11350	8540	5400	2960	2155	1950	1520	...
17	.....	.....	1316	1369	13800	8230	5200	2820	2100	1950	1520	....
18	.....	1085	1343	1395	18660	9200	4900	2820	2100	1900	1497	...
19	.....	.....	1343	1395	25810	9200	4800	2755	2100	1900	1497	....
20	.....	.....	1343	1420	26525	10350	4600	2890	2050	1850	1473	....
21	1137	.....	1316	1502	22230	10775	4500	3660	2050	1850	1473	1380
22	.....	.....	1369	1585	19375	10350	4300	3240	2050	1850	1473	1380
23	.....	.....	1369	1672	12725	10350	4220	2890	2050	1850	1473	....
24	.....	.....	1369	1808	12200	11200	4220	2820	2155	1800	.....	1380
25	.....	1112	1369	1902	12200	9950	4220	2690	2320	1800	.....	1381
26	.....	.....	1395	1902	13850	10350	4140	2625	2320	1800	.....	1380
27	.....	.....	1369	1855	17230	8850	4060	2560	2210	1750	.....	....
28	1085	.....	1343	1672	20805	8850	3980	2560	2155	1750	.....	1240
29	.....	.....	1343	1760	20090	8695	3820	2560	2155	1750	.....	1192
30	.....	.....	1316	2050	19375	8540	3740	2500	2100	1750	.....	1192
31	.....	.....	1316	....	15800	....	3590	2440	....	1750	.....	....

Daily Discharge in Second-feet of Yellowstone River, at Livingston, Mont., for 1902.

1	1205	a	1280	1280	1677	12850	9550	5650	2592	1770	1397	1205
2	1205	....	1317	1317	1640	10950	9550	5453	2505	1715	1397	1205
3	1440	1000	1280	1317	1640	9950	10110	5258	2505	1715	1355	1135
4	1495	1030	1280	1317	1640	9750	9710	5010	2427	1715	1355	1135
5	1440	1135	1242	1317	1677	10350	9550	4912	2350	1677	1242	1205
6	1355	1135	1280	1355	1677	10350	9150	4717	2350	1677	1205	1135
7	1440	1135	1280	1355	2010	10350	8950	4620	2277	1677	1280	a
8	1440	1135	1280	1355	2427	11050	8647	4522	2277	1640	1397	1000
9	1440	....	1242	1317	4125	12950	8408	4425	2205	1640	1397	1205
10	1440	1280	1280	1317	5356	14350	8350	4325	2205	1640	1397	1205
11	1355	1355	1280	1340	6058	14650	8350	4225	2137	1640	1440	1135
12	....	1355	1280	1340	6551	14150	8505	4225	2070	1640	1440	1135
13	1205	1355	1280	1317	7960	13550	8545	4225	2010	1595	1440	1205
14	1205	1280	1242	1317	8606	14250	8545	4125	2010	1595	1440	...
15	1280	1280	1280	1317	9850	11850	8350	4125	1950	1595	1397	1000
16	1205	1440	1280	1355	9110	11210	8155	4025	1950	1550	1355	96

a Ice.

Daily Discharge of Yellowstone River, for 1902, Continued.

Day	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	1205	1495	1280	1397	9250	10710	8117	4025	1950	1550	1355	1000
18	1355	1440	1280	1495	8351	10550	7823	4025	1950	1550	1355	1000
19	1317	1440	1280	1640	7433	10250	7472	3910	1950	1495	1317	1060
20	1280	1280	1280	2137	6453	9910	7277	3840	1887	1495	1317	1135
21	1205	1280	1280	1825	6156	10110	7180	3645	1887	1495	1242	1135
22	1280	1280	1280	1550	5590	10350	7141	3445	1825	1450	1170	1135
23	1317	1280	1280	1825	5453	10650	6985	3347	1825	1440	1205	1205
24	a	1280	1280	1715	5690	10810	6887	3250	1825	1440	1242	1135
25	a	1280	1280	1640	6848	10550	6790	3150	1825	1440	1280	1280
26	a	1280	1317	1550	7921	10610	6650	3050	1770	1440	1205	1355
27	a	1280	1317	1550	9710	10250	6453	2927	1770	1440	1170	1205
28	a	1280	1280	1550	11050	10350	6195	2805	1770	1440	1170	....
29	a	....	1170	1595	11650	9650	6097	2742	1770	1440	1170	1060
30	a	....	1170	1640	12750	9750	6000	2680	1770	1440	1135	1060
31	1000	....	1205	....	13350	....	5853	2680	....	1397	....	1060

Daily Discharge in Second-feet of Marias River, at Shelby, Mont., for 1902..

1	.....	.....	.....	.....	720	6633	2399	1020	540	425	425	480
2	.....	.....	.....	.....	720	6457	3983	1020	480	425	425	480
3	.....	.....	.....	.....	855	6105	6457	935	425	425	425	480
4	.....	.....	.....	352	720	4883	12793	935	480	425	425	480
5	.....	.....	.....	357	660	4355	14553	935	540	425	425	480
6	.....	.....	.....	349	600	3983	10153	855	540	425	373	480
7	.....	.....	.....	337	660	3807	7161	780	540	425	425	480
8	.....	.....	.....	337	855	3631	5929	720	480	425	425	480
9	.....	.....	.....	333	935	3103	5059	780	425	425	373	480
10	.....	.....	.....	373	1190	3631	4531	935	373	425	425	480
11	.....	.....	.....	373	1190	4159	4159	780	425	425	425	480
12	.....	.....	.....	373	2047	4159	3807	720	425	425	480	600
13	.....	.....	.....	373	2047	3807	3103	600	425	425	720	660
14	.....	.....	.....	373	2047	3279	3103	600	425	425	660	660
15	.....	.....	.....	425	2927	3103	3103	600	425	425	660	600
16	.....	.....	.....	300	5235	2927	2927	540	480	425	600	660
17	.....	.....	.....	333	4707	3103	2927	540	425	425	660	600
18	.....	.....	.....	333	4159	2927	2399	600	425	425	600	600
19	.....	.....	.....	333	4159	2575	2399	425	480	425	600	600
20	.....	.....	.....	333	3807	2575	2223	373	425	425	600	660
21	.....	.....	.....	600	11913	2399	2223	373	425	425	540	660
22	.....	.....	.....	720	18073	2223	2047	480	600	425	600	600
23	.....	.....	.....	660	11385	2399	1871	533	540	425	600	600
24	.....	.....	.....	600	11737	2047	1520	540	425	425	600	600
25	.....	.....	.....	540	11033	2399	1402	660	480	425	540	600
26	.....	.....	.....	480	6457	2399	1520	720	425	425	540	660
27	.....	.....	.....	540	5753	2927	1520	600	425	425	480	660
28	.....	.....	.....	540	6633	2751	1695	600	425	425	480	660
29	.....	.....	.....	540	6809	2575	1402	480	480	425	480	590
30	.....	.....	.....	660	7513	2751	1190	425	480	425	480	480
31	.....	.....	.....	.....	6809	....	1190	....	....	425	....	480

a Ice.

Daily Discharge in Second-feet of St. Mary River, at Outlet of Lower Lake, for 1902.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	182	2700	1560	1140	540	267	182	97
2	225	2640	1680	1080	480	267	182	97
3	310	2640	1980	1020	480	267	182	97
4	310	2220	2940	960	480	267	182	97
5	310	2040	3000	960	437	225	140	97
6	310	1800	2880	960	437	225	140	97
7	310	1500	2640	900	437	225	140	a
8	310	1500	2520	900	437	225	140	a
9	97	395	1620	2340	900	395	225	140	a
10	97	395	1620	2160	780	395	225	140	a
11	97	395	1680	2040	840	352	225	140	a
12	97	395	1620	2040	840	352	225	140	a
13	97	395	1620	1800	840	352	225	140	a
14	97	437	1500	1800	840	352	225	140	a
15	140	840	1680	1560	840	310	225	140	a
16	140	960	1620	1560	840	352	225	140	a
17	140	1620	1560	1560	780	352	225	140	a
18	140	1620	1440	1500	780	310	225	140	a
19	140	1860	1440	1500	780	310	225	140	a
20	97	2400	1440	1440	780	310	225	140	a
21	97	2640	1320	1440	780	310	225	140	a
22	140	2640	1200	1440	720	310	225	140	a
23	182	2640	1140	1380	720	310	225	140	a
24	225	2820	960	1440	660	310	225	140	a
25	225	2700	960	1440	660	267	225	97	a
26	140	2640	1320	1500	660	267	182	97	182
27	140	2640	1260	1380	660	267	182	97	225
28	140	2040	1440	1380	660	267	182	97	182
29	140	2100	1440	1320	600	267	182	97	182
30	182	2640	1320	1200	600	267	182	97	140
31	2640	....	1140	600	...	182	..	140

Daily Discharge in Second-feet of St. Mary River, at Main, Mont., for 1901.

1	.....	.....	.....	.....	.....	.....	.....	1574	655	465	328	278
2	.....	.....	.....	.....	.....	.....	.....	1515	655	465	328	278
3	.....	.....	.....	.....	.....	.....	.....	1338	632	445	312	278
4	.....	.....	.....	.....	.....	.....	.....	1279	632	425	312	268
5	.....	.....	.....	.....	.....	.....	.....	1220	632	425	278	268
6	.....	.....	.....	.....	.....	.....	.....	1161	655	425	278	268
7	.....	.....	.....	.....	.....	.....	.....	1161	677	425	278	258
8	.....	.....	.....	.....	.....	.....	.....	1102	677	425	268	258
9	.....	.....	.....	.....	.....	.....	.....	1102	655	425	278	258
10	.....	.....	.....	.....	.....	.....	.....	1043	609	425	312	258
11	.....	.....	.....	.....	.....	.....	.....	1043	587	425	328	248
12	.....	.....	.....	.....	.....	.....	.....	984	567	425	365	248
13	.....	.....	.....	.....	.....	.....	.....	937	567	425	328	248
14	.....	.....	.....	.....	.....	.....	2317	937	567	405	328	248
15	.....	.....	.....	.....	.....	.....	2199	842	567	405	312	238
16	.....	.....	.....	.....	.....	.....	2164	842	587	405	278	238

a Ice.

Daily Discharge of St. Mary River, for 1901, Continued.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	2046	795	587	405	278	238
18	1928	795	567	405	278	232
19	1928	766	567	405	278	232
20	1928	766	567	405	268	232
21	1869	766	546	385	268	232
22	1869	736	546	385	268	227
23	1869	736	525	385	268	227
24	1810	736	505	385	278	227
25	1869	704	505	365	278	227
26	1869	704	505	365	278	221
27	1810	704	505	365	295	221
28	1810	677	485	365	295	221
29	1751	677	485	365	295	221
30	1633	677	485	328	295	221
31	1574	655	...	328	...	221

Daily Discharge in Second-feet of St. Mary River, at Main, Mont., for 1902.

1	.....	.....	.....	...	373	4130	2910	1507	750	293	.....	.....
2	.....	.....	.....	...	394	3886	3276	1406	690	330	.....	.....
3	.....	.....	.....	...	394	3642	6448	1328	612	330	.....	.....
4	.....	.....	.....	...	415	3276	6692	1252	612	330	.....	.....
5	.....	.....	.....	...	458	3154	5838	1214	612	293	.....	.....
6	.....	.....	.....	185	479	2910	4862	1214	612	293	.....	.....
7	.....	.....	.....	185	501	2788	4618	1214	612	293	.....	.....
8	.....	.....	.....	195	544	2788	3642	1214	612	275	.....	.....
9	.....	.....	.....	195	630	2910	3154	1252	565	275	.....	.....
10	.....	.....	.....	195	790	3032	2910	1252	565	275	.....	.....
11	.....	.....	.....	208	960	3032	2666	1252	565	257	.....	.....
12	.....	.....	.....	208	1202	2910	.....	1214	541	257	.....	.....
13	.....	.....	.....	220	1568	2910	2300	1176	541	257	.....	.....
14	.....	.....	.....	220	2178	2788	2178	1138	518	275	.....	.....
15	.....	.....	.....	220	2544	2910	2056	1200	494	257	.....	.....
16	.....	.....	.....	245	2910	2788	1934	1062	518	257	.....	.....
17	.....	.....	.....	273	3398	2666	1934	1062	541	257	.....	.....
18	.....	.....	.....	273	3520	2544	1812	1062	494	275	.....	.....
19	.....	.....	.....	305	3154	2422	1690	1024	494	.....	.....	.....
20	.....	.....	.....	305	3886	2300	1568	986	470	.....	.....	.....
21	.....	.....	.....	305	4808	2178	1690	1024	424	.....	.....	.....
22	.....	.....	.....	321	4252	2544	1690	986	377	.....	.....	.....
23	.....	.....	.....	321	4130	2544	1812	910	330	.....	.....	.....
24	.....	.....	.....	338	4252	2544	1812	910	293	.....	.....	.....
25	.....	.....	.....	338	4130	2544	1934	910	311	.....	.....	.....
26	.....	.....	.....	356	3886	2788	1934	910	311	.....	.....	.....
27	.....	.....	.....	356	3947	2788	1934	876	293	.....	.....	.....
28	.....	.....	.....	356	4069	2788	1934	876	293	.....	.....	.....
29	.....	.....	.....	373	4374	2788	1812	842	293	.....	.....	.....
30	.....	.....	.....	373	4618	2910	1751	811	293	.....	.....	.....
31	.....	.....	.....	...	4252	.....	1629	750	...	.....	.....	.....

Daily Discharge in Second-feet of Milk River, at Havre, Mont., for 1901.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1640	280	280	680	350	65	12	80	80	95
2	4040	280	280	480	350	52	12	80	80	95
3	2960	280	280	360	290	40	10	80	65	130
4	1820	230	2540	360	260	40	10	80	65	130
5	1340	255	1700	360	260	40	10	65	65	230
6	1100	255	1100	360	230	40	12	65	65	260
7	2540	230	1460	360	203	40	19	80	..	260
8	2900	180	730	360	203	40	23	80	80	260
9	1340	180	730	332	290	40	23	80	80	....
10	1100	180	540	332	350	40	23	95	80	....
11	1025	155	450	360	462	40	32	95	80	....
12	1025	155	360	332	310	40	52	95	95	...
13	1100	155	360	780	230	32	52	95	80	....
14	1062	155	360	1340	203	23	23	95	80	....
15	1280	115	305	760	203	23	80	95	80	....
16	890	205	305	760	175	19	65	80	80	....
17	1100	115	280	820	175	19	65	80	80	....
18	890	115	280	760	153	23	80	80	80	....
19	780	135	230	760	112	23	95	80	80	....
20	730	135	230	650	95	23	95	80	80	....
21	680	155	255	600	80	19	95	80	80	....
22	540	135	585	500	80	19	95	80	..	....
23	510	135	680	500	65	19	95	80	..	....
24	480	180	890	500	65	15	95	80	..	....
25	680	255	830	500	65	15	95	80	.	....
26	510	280	780	500	80	13	95	80	..	....
27	510	332	730	425	65	13	95	80	80	....
28	480	318	630	387	65	13	80	80	80	....
29	420	318	780	350	95	13	80	80	80	....
30	360	280	730	350	80	13	80	80	95	....
31	360	...	680	....	65	12	..	80	..	....

Daily Discharge in Second-feet of Milk River, at Havre, Mont., for 1902.

1	a	a	412	161	188	465	630	710	250	300	250	a
2	a	a	412	161	200	465	630	630	250	250	300	a
3	a	a	412	161	200	2314	989	465	250	250	300	a
4	a	a	335	250	188	3442	2408	412	212	250	212	a
5	.....	a	310	235	188	4616	3560	412	212	250	212	a
6	.....	a	222	222	180	4147	4147	355	212	250	212	a
7	.....	a	200	188	180	4147	8842	355	212	250	212	180
8	180	a	200	188	180	1935	8842	355	212	250	a	a
9	180	a	200	188	188	1462	4147	355	212	212	a	a
10	.....	a	250	188	188	1368	2973	355	180	212	180	a
11	.....	a	465	235	200	1178	2314	355	180	212	a	a
12	.....	a	335	268	200	989	1935	355	180	250	a	a
13	.....	a	222	268	200	989	2124	355	180	250	a	a
14	.....	a	200	250	200	895	2124	355	180	250	a	180
15	.....	a	200	235	200	800	1935	355	180	250	a	a
16	.....	a	200	235	210	1178	1935	300	212	250	a	a

a Ice.

Daily Discharge of Milk River, for 1902, Continued.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17	...	a	200	210	222	1178	1462	300	212	250	a	a
18	180	a	200	200	335	1178	1178	300	195	250	a	a
19	...	210	200	188	335	1178	989	300	180	250	a	a
20	...	250	200	180	370	1178	1178	300	180	250	a	a
21	...	210	200	170	370	1178	1178	300	180	250	a	a
22	...	210	200	170	1084	1178	989	300	212	250	a	a
23	...	188	200	180	3912	1084	1178	250	250	250	a	a
24	...	188	222	180	7081	1084	1178	250	250	250	a	a
25	180	188	235	180	7668	989	1178	300	300	250	a	a
26	...	188	250	180	3325	895	989	412	300	250	a	a
27	...	222	250	170	2503	800	895	355	250	250	a	a
28	...	222	235	170	1557	800	895	300	250	250	a	a
29	200	170	989	630	800	300	250	250	a	a
30	180	...	170	180	574	630	710	250	300	250	a	a
31	170	...	574	...	710	250	...	250	.....	a

a Ice.

Discharge Measurements of Rivers of Montana.

River.	Date.	Discharge Second-ft.
Milk at Malta, Montana.....	July 31, 1902	525.
" " " ".....	Aug. 21, 1902	259.
" " " ".....	Sept. 10, 1902	166.
" " " ".....	Sept. 25, 1902	165.35
" " " ".....	Oct. 6, 1902	271.3
" " " ".....	" 11, 1902	197.97
" " " ".....	" 17, "	174.0
" " " ".....	" 24, "	171.0
" " " ".....	" 31, "	257.0
" " " ".....	Nov. 7, "	210.0
Swift Current at Main, Montana.....	Apr. 9, "	67.9
Missouri at Townsend, Montana.....	Apr. 14, "	2840
" " " ".....	July 14, "	6547
" " " ".....	Aug. 28, 1902	2350
St. Mary near Cardston, Alberta, Inter. Line, B. C....	Oct. 11, "	501.
" " " ".....	" 23, "	387.
Two Medicine at Midvale, Montana.....	" 15, "	34.0
" " " ".....	" 15, "	47.0
Missouri at Cascade, Montana.....	July 21, 1902	5537
" " " ".....	Sept. 9, "	1891
" " " ".....	Nov. 6, "	3131
Crow Creek, Radersburg, Montana.....	Aug. 28, "	18.14
" " " ".....	Aug. 28, "	18.89

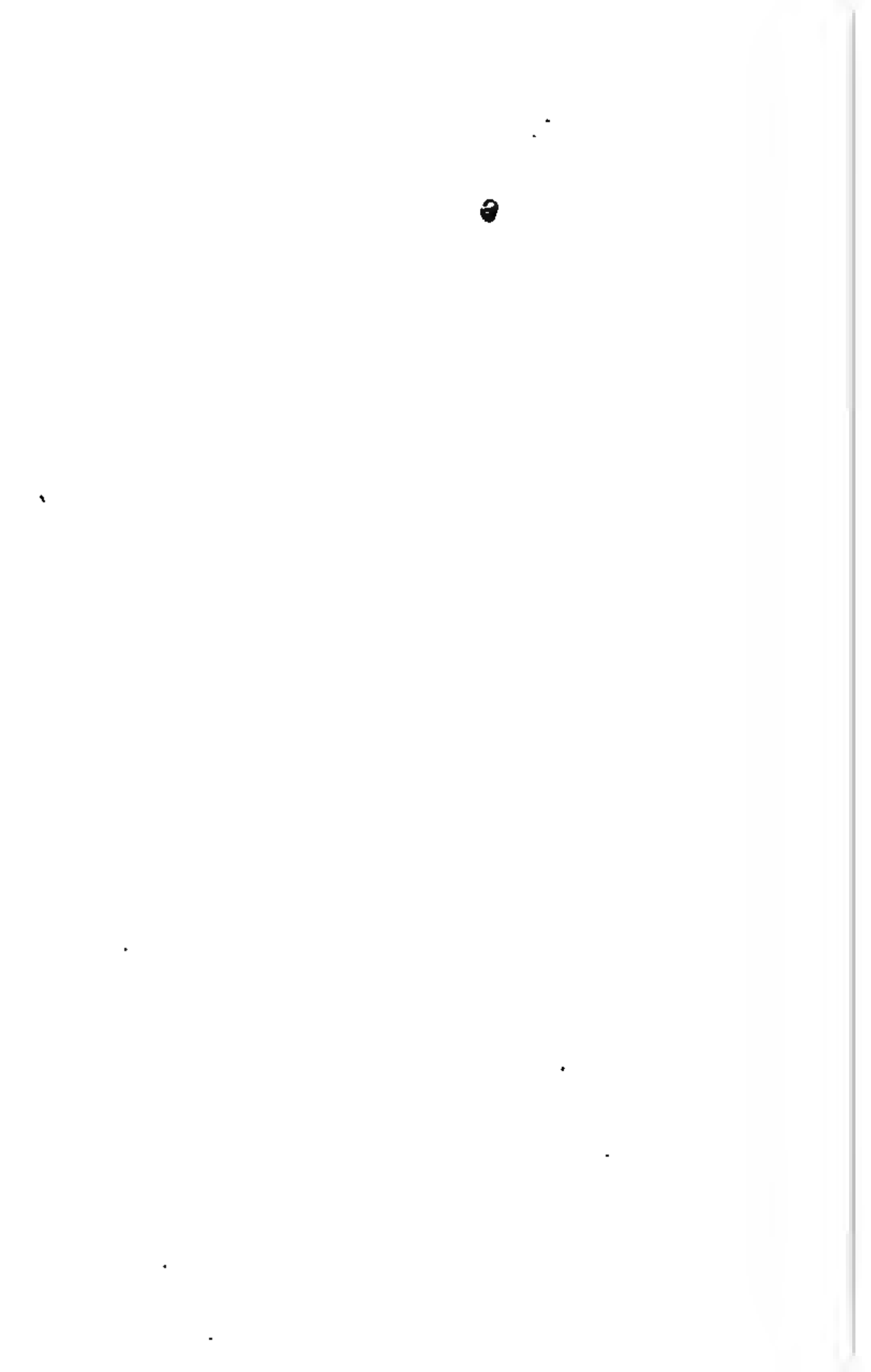
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TENTH

ANNUAL REPORT

OF THE

AGRICULTURAL

EXPERIMENT STATION

OF THE

AGRICULTURAL COLLEGE

OF

MONTANA

FOR THE YEAR ENDING 1903.

BOZEMAN



CHRONICLE

1904.



LETTER OF TRANSMITTAL.

BOZEMAN, MONTANA, December 31, 1903.

To His Excellency, JOSEPH K. TOOLE,
Governor of Montana.

DEAR SIR:—In accordance with the Congressional Act of March 2, 1887, I have the honor to transmit herewith the tenth annual report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1903, the results of investigations of the several departments are reported to the end of the State year, November 30, 1903.

Very respectfully,

F. B. LINFIELD,
Acting Director.

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MONTANA AGRICULTURAL EXPERIMENT STATION.

STATE BOARD OF EDUCATION.

JOSEPH K. TOOLE, Governor,	} Ex-Officio.....	Helena
JAMES DONOVAN, Attorney-General,		
W. W. WELCH, Supt. of Public Instruction,		
J. M. EVANS.....		Missoula
C. R. LEONARD.....		Butte
N. W. McCONNELL.....		Helena
W. M. JOHNSTON.....		Billings
O. P. CHISHOLM.....		Bozeman
J. G. MCKAY.....		Hamilton
G. T. PAUL.....		Dillon
N. B. HOLTER.....		Helena

EXECUTIVE BOARD.

WALTER S. HARTMAN, President.....	Bozeman
JOHN M. ROBINSON, Vice-President.....	Bozeman
PETER KOCH, Secretary.....	Bozeman
JOSEPH KOUNTZ.....	Bozeman
E. B. LAMME.....	Bozeman

STATION STAFF.

*S. FORTIER, Ma. E.....	Director and Irrigation Engineer
F. B. LINFIELD, B. S. A.....	Vice Director and Agriculturist
F. W. TRAPHAGEN, Ph. D., F. C. S.....	Chemist
*J. W. BLANKINSHIP, Ph. D.	Botanist
R. A. COOLEY, B. Sc.....	Entomologist
R. W. FISHER, B. S.....	Assistant Horticulturist
EDMUND BURKE.....	Assistant Chemist

*On leave of absence.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to

THE DIRECTOR,
MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

REPORT OF THE TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1902-1903.

DR.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1903, as per Act of Congress approved March 2, 1887.....\$15,000.00

CR.

By Salaries.....	\$ 8,818.50
Labor.....	2,218.85
Publications.. ..	1,368.87
Postage and stationery.....	250.21
Freight and express.....	356.25
Heat, light, water and power.....	284.67
Chemical supplies	217.60
Seeds, plants and sundry supplies	499.15
Fertilizers.....	40.80
Library	235.18
Tools, implements and machinery.....	237.71
Furniture and fixtures.....	300.00
Scientific apparatus.....	107.21
Contingent expenses.....	65.00

Total.....\$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1903; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00, and the corresponding disbursements \$15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed:

Attest:

PETER KOCH,

Custodian.

E. B. LAMME,

PETER KOCH,

Auditors.

REPORT OF DIRECTOR.

In accordance with the resolution of the Station staff passed one year ago, this Tenth Annual Report, while giving the financial statement to June 30th, will include a report of the work of the station up to November 30th, 1903.

In addition to the financial statement it is desired to place on record a statement of the changes, additions and improvements made during the year together with a summary of the work completed or in progress up to date.

It is a pleasure to record that the year has added considerable to the equipment of the Station. The State Legislature of 1903 appropriated \$5,500 for a new building and equipment for a central heating plant for the Station and agricultural buildings. \$3,000 was also appropriated for a seed house and granary. Both of these buildings are finished and in use; \$13,000 was appropriated for a cattle and dairy barn and the contract has been let for this building. In addition to this the fund for Station maintenance was increased to \$5,000. Besides enabling us to continue the irrigation investigations over the state this increased appropriation has permitted us to remove several old buildings and sheds, thus clearing the sites for the new buildings and giving us material for buildings needed in other places. The roofs of several shed were used in fitting up an excellent implement shed 25 feet wide by 150 feet long. The old log granary has been moved and will form the center of a new hog pen.

Several hundred rods of fencing have also been built largely from old material on the place and several hundred rods of earth roads on the farm and around it have been graded.

In co-operation with the College, the Dairy building has been quite thoroughly equipped with butter-making, cheese-making and milk testing apparatus. Improved facilities for caring for the product and for handling it were also provided. Material equipment has also been added to other departments of the Station.

The work of the various departments has progressed satisfactorily during the year and the report of such of this work as is ready for publication is given as part of this report. The results of several investigations made during the year have been published or are now being prepared and will be published in bulletin form.

In the agricultural department for the past year considerable work has been done preliminary to an increase in the number of livestock to be kept on the farm, and to the increase in livestock experiments, particularly with breeding stock, with dairy cows and with dairy manufacturing. With the completion of the plans outlined for this coming year, the department will be able to enter vigorously upon the new lines of work. During the year the Poultry department has been transferred to the agricultural department as it is logically a branch of the animal industry work.

A rather unexpected duty fell to the lot of the agricultural department when the College was asked to collect, prepare, and install the agricultural exhibit from Montana at the St. Louis World's Fair. It has added considerable to the work of this department for this year.

The increase in the appropriation from the State has enabled us to continue the co-operative work with the Irrigation division of the Department of Agriculture at Washington; the department's proposal being to duplicate the amount we are putting into this work. The irrigation department has also been continuing its observations on irrigation conditions over the state.

The extra fund, with help from the agricultural department at Washington, has also enabled us to make a beginning in more extended study of the agricultural conditions in other parts of the

state through the starting of temporary substations in Cascade and Yellowstone counties, the former to study dry land conditions, and the latter for the study of drainage and alkali problems. We have in contemplation yet another station to test the advantage of fall and winter irrigation.

The botanical department has been largely concerned in the study and classification of the botanical specimens collected over the state for several years past and in preparing for publication the results of this study, which will soon be issued in bulletin form. These studies will form the basis for much future work.

The chemical department, has been busy preparing for publication the results of some years' work on sugar beets, pure food investigations, and soil and alkali studies. These results will appear in bulletin form in the near future.

The entomological department has been largely concerned in the study of the grasshopper pest in the eastern part of the state. Work with the codling moth and with bees has also been kept up during the year. The Station Entomologist was made State Entomologist by the last State Legislature and \$300 was apportioned for his traveling expenses. This has aided materially in extending the field of observation of the department, but has also increased the duties.

The horticultural department has devoted considerable time to renovating the orchard during the year. Observations have been continued on the fruits, trees and bushes and on various annual vegetable crops. Plans are being laid for extensive work in the originating of varieties of fruits and vegetables adapted to Montana conditions.

NEEDS OF THE STATION.

Considered as a whole, the most pressing need of the Experiment Station is more room for office, laboratory and library. On two floors of a building, 45x50, are located the offices and laboratories of five departments of the Station and in addition the Station library. In these same rooms the officers have to meet

their College classes. To properly carry on our work additional room is absolutely essential.

The Station is also anxious to extend its work, particularly in the line of veterinary science, but with the limited room, there is at present no place for the laboratories necessary for such a department.

A new building for the biological departments of botany, entomology and veterinary science would relieve the pressure for space in the station building and afford the necessary room for those departments to properly carry on their work. It is hoped that such a building may be provided in the very near future.

Agricultural books, and scientific books relating to agriculture have increased very rapidly in the past few years. To do the most efficient work the Station officers must have ready access to a wide range of scientific books. All of the departments feel the need of much better library facilities. More books are needed and also the means to properly classify and index them for ease of reference.

The agricultural department has been favored during the year in the erection of several new buildings and in equipment for work in other directions. Some buildings are yet needed, notably a sheep barn for our breeding and experimental flock, a good steer-feeding shed and a modern piggery.

The past winter has very forcibly shown the need of good sheds for our feeding tests and particularly for the storage of the hay. With continued snowy and wet weather it was practically impossible to more than guess at the weight of the hay fed in the experiment with sheep and steers, as we had to feed them from the stack. With present buildings the stack is the only place for keeping the hay.

Additions are also needed to our poultry buildings to place this work on a basis where it can be most economically and efficiently handled.

With the proposed increase in livestock another quarter section of land will be valuable to provide the necessary feed. A laboratory and equipment for the work in soil physics is also needed.

To make our study of livestock problems as complete as pos-

sible several breeds of purebred stock should be kept on the Station farm. At present our equipment in this direction is very meager indeed.

In addition to more laboratory space, the entomological department needs a small orchard of various kinds of fruit and other trees, where the life histories of insects pests may be worked out and experiments made in the control or destruction of these pests. The present orchard which is used for the study of different varieties of fruit trees is not available for much of the work of the entomological department.

For the horticultural department an horticultural laboratory and propagating house, are needed if the department is expected to do its best work. The present greenhouses are in very poor condition and not at all suitable for the work demanded. They are, moreover, not in a proper place, but it would be a useless expense to move them. Parts of these houses could be used to advantage in fitting up an horticultural laboratory. There is probably no line of work that tends to encourage home building on the farm so much as that of horticulture. The man who plants a tree is banking on the future and means to stay. Fruit, shade trees and flowers lend beauty as well as comfort to the home.

Montana possesses many very fine native flowers and flowering shrubs, that deserve a test as ornamentals and of introduction to the home of the people.

Enough work has been done to show that good fruit, fruit of high quality, can be grown in Montana. Much yet remains to be done to find the varieties best suited to the country and to the various valleys. The Station is anxious to take up this work, but must await the facilities for doing it.

PUBLICATIONS.

The following bulletins were published during the year:

Bulletin No. 43.—The Duty of Water in Montana. This bulletin is a study of the actual use of water on a large number of farms in various parts of the state and the results from that use.

A large number of the observations are graphically presented. 56 pages.

Bulletin No. 44.—Apple Growing in Montana. Gives some general directions on the planting and care of an apple orchard together with a list of the varieties that are recommended for the various valleys of the state. 16 pages.

Bulletin No. 45.—The Loco and Some Other Poisonous Plants in Montana. This bulletin reports the results of observations and inquiry in regard to the causes of stock poisoning on the range and suggests methods of management and treatment to overcome or to reduce the losses from these causes. 32 pages.

Bulletin No. 46.—Two Insect Pests. This reports a study of the lives and habits of two insect pests that attack rose bushes and poplar trees and recommends methods for their control. 14 pages.

Bulletin No. 47.—Sheep Feeding. Reports the results of the sheep feeding experiments on the Station farm during the winter of 1902-3. 32 pages.

Bulletin No. 48.—Steer Feeding. Records the results of the steer feeding experiments with a car of steers during the winter of 1902-3. 16 pages.

Bulletin No. 49.—Contagious Abortion in Montana. Records the results of some inquiries made as to the prevalence of this disease among cattle in the state and outlines methods for its control. 12 pages.

Bulletin No. 50.—Poultry Management and Poultry Diseases. Gives some rules for the proper care and feeding of poultry and the treatment of some diseases most troublesome to the Montana farmers. 20 pages.

Bulletin No. 51.—First Annual Report of State Entomologist. Deals with various insect pests and gives remedies for the control of the same. It gives particular attention to the grasshoppers and fruit pests and contains also a short paper on the toad as a destroyer of insects. 76 pages.

Tenth Annual Report.

FARMERS' INSTITUTES.

During the past year the Director has continued to act as a director of the Farmers' Institute Board and also as Secretary of the Board. This work has taken considerable time, particularly as the work is in somewhat of a formative stage. Once thoroughly organized much less time will be required. There has also been considerable demand on the time of the Station staff for this work. When more thoroughly systematized, however, it is believed that this work will prove more helpful than detrimental to the Station workers. The opportunity to get acquainted with the people of various parts of the state and to study at first hand the problems that confront the farmer will help to keep our work in close touch with the agricultural needs of the state.

STATION STAFF.

On the first of July, 1903, Director Fortier obtained leave of absence for one year to take charge of irrigation work for the U. S. Department of Agriculture in California. The writer was appointed vice-director and to me fell the work of the Director's office. Later in the season Dr. F. W. Traphagen who had been chemist of the Station since its organization in 1893, resigned to accept a more lucrative position in the Colorado School of Mines, Golden, Colo. Because of his long association with the work and his thorough acquaintance with conditions over the state, Dr. Traphagen's departure was a serious loss to the Station.

Prof. V. K. Chesnut, who for some years has been connected with the Bureau of Plant Industry of the Department of Agriculture at Washington, D. C., in investigations of poisonous plants, has been elected to the position of chemist left vacant by Dr. Traphagen's resignation. Dr. Chesnut brings to his work ripe experience in agricultural experimentation.

An addition to the Station staff has been the election of Mr. W. J. Elliott, of Minnesota, to the position of assistant in dairy-

ing. Mr. Elliott is a graduate of the Ontario Agricultural College and spent some years in practical creamery work in Ontario and in Minnesota.

Mr. H. C. Gardiner, student in charge of the poultry, resigned his charge at the end of the year, and the work was turned over to the agricultural department.

CORRESPONDENCE.

The Station correspondence has shown no diminution during the year. This correspondence is a severe tax upon the time of the staff as many of the letters require extended answers and some considerable research, yet it is cheerfully undertaken as it shows an increasing interest in the work of the Station over the state as well as faith in the results obtained.



LIST OF STATION PUBLICATIONS.

1. Organization—Announcements.
2. Smuts of Wheat, Oats and Barley.
3. Pig Feeding.
4. Glanders.
- * 5. First Annual Report, Crop Statistics of Gallatin County.
- * 6. Measurement of Water.
- * 7. Small Grains and Potatoes.
- * 8. Second Annual Report—Crop Statistics of Gallatin County—
Parasitic Ictero—Haematuria of Sheep.
- * 9. Potatoes.
- *10. Small Grains, Wheat, Oats, Barley.
- *11. Devices for Obtaining a Constant Flow in Laterals with Variable
Heads in the Main Canals or Reservoirs.
12. Third Annual Report, Spaying of Mares.
13. Drinking Water.
14. Montana Swine Feeding.
15. Larkspur Poisoning of Sheep.
16. Fourth Annual Report.
17. An Army Cut Worm—The Grain Aphis.
18. The Alkali Soils of Montana.
- *19. The Sugar Beet in Montana.
20. Fifth Annual Report.
- *21. Sheep Feeding.
- *22. Thirteen Botanical Subjects.
- *23. Injurious Fruit Insects; Insecticides; Insecticide Apparatus.
24. Sixth Annual Report.
25. Paris Green, and London Purple.
- *26. Poultry Raising.
- *27. Live Stock Feeding Tests, Beef Cattle, Lambs and Swine.
- *28. Seventh Annual Report.
- *29. Quantity of Water Used in Irrigation.
30. Weeds of Montana.

*Out of Print.

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31. Report of Grazing and Feeding Tests, Beef Cattle and Lambs.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
34. Farmers' Weirs.
35. Report of Feeding Tests.
36. Forage Conditions in Central Montana.
37. Pork Production in Montana.
38. Food Adulterations.
39. Sheep Feeding in Montana.
40. Root Crops in Montana.
41. Sugar Beets, (1902).
42. The Codling Moth.
43. Ninth Annual Report.
44. The Duty of Water.
45. Apple Growing in Montana.
46. The Loco, and Some Other Poisonous Plants in Montana.
47. Two Insect Pests.
48. Sheep Feeding.
49. Steer Feeding.
50. Contagious Abortion in Montana.
51. Poultry Management and Poultry Diseases.
52. First Annual Report of the State Entomologist.
53. Tenth Annual Report.

*Out of Print.

DONATIONS AND LOANS.

Manhattan Malting Co., Manhattan, Mont.

500 pounds malt sprouts; 2 samples of barley.

Chicago Weekly Livestock Report.

1 bound copy of Report for 1903.

Minnesota Experiment Station.

5 samples wheat.

North Dakota Experiment Station.

3 samples wheat; 3 samples oats; 2 samples barley and 2 of corn.

Indian Head Experiment Station, N. W. T., Canada.

4 samples wheat; 5 samples of oats; 3 samples of barley and 4 of peas.

Brandon Experiment Station, N. W. T., Canada.

8 samples wheat; 2 samples oats; 2 samples barley; 3 of peas and 1 of spelt.

Mrs. Dr. Waters, Bozeman.

Plants and flower seeds.

Miss Davis, Bozeman.

Greenhouse plants.

Mrs. John Widdecombe, Bozeman.

Plants.

W. Atlee Burpee & Co., Philadelphia, Pa.

Flower and garden seeds.

Wallace Machinery Co., Champaign, Ill.

1 Wallace Power Sprayer.

Greening Bros. Nursery Co., Monroe, Mich.

1 "Auto Spray."

S. A. Hazeltine, Springfield, Mo.

1 Universal Dust Sprayer.

F. E. Myers & Bro., Ashland, Ohio.

1 Myers' Hydraulic Spray Pump.

1 " Perfect Double Acting Barrell Spray Pump

2 " Hand Pumps.

1 set fixtures, Y's, nozzles, etc.

EXCHANGE LIST.

The American Fancier, Johnstown, N. Y.
American Poultry Advocate, Syracuse, N. Y.
American Fertilizer, Philadelphia, Pa.
Belt Valley Times, Belt, Mont.
Butte Inter-Mountain, Butte, Mont.
Butchers' Advocate, New York.
Beet Sugar Gazette, Chicago.
Chinook Opinion, Chinook, Mont.
Chicago Daily Drivers' Journal, Chicago.
Carbon County Chronicle, Gebo, Mont.
Chicago Livestock World, Chicago.
Daily Independent, Helena, Mont.
Dillon Tribune, Dillon, Mont.
Elgin Dairy Report, Elgin, Ill.
Farmer & Breeder, Sioux City, Iowa.
Farm Journal, Philadelphia, Pa.
Feather, Washington, D. C.
Farmer's Guide, Huntington, Ind.
Florist's Review, Chicago.
Farmer's Review, Chicago.
Farming World, Toronto, Can.
Farm Poultry, Des Moines, Iowa and Boston, Mass
Fruit Grower & Farmer, Missoula, Mont.
Farm, Field & Fireside, Monthly, Chicago.
Farmer's Voice & National Rural, Chicago.
Gleanings in Bee Culture, Medina, Ohio.
Glendive Independent, Glendive, Mont.
Great Falls Weekly, Great Falls, Mont.
Holstein-Friesian, Brattleboro, Vermont.
Home Maker, Des Moines, Iowa.
Home & Farm, Louisville, Ky.
Irrigation Age, Chicago.
Inter Mountain Farmer, Salt Lake City, Utah.

Inter Lake, Kalispell, Mont.
Independent, Miles City, Mont.
Jersey Bulletin, Indianapolis, Ind.
Livingston, Post, Livingston, Mont.
Modern Farmer, St. Joseph, Mo.
Modern Farmer, St. Joseph, Mo.
Milwaukee Weekly Journal, Milwaukee, Wis.
Mining & Scientific Press, San Francisco, Calif.
The Madisonian, Virginia City, Mont.
National Farmer, Winona, Minn.
Northwestern Tribune, Stevensville, Mont.
New York Herald, New York.
Northwest Poultry Journal, Salem, Oregon.
National Stockman & Farmer, Chicago.
Opportunity, St. Paul, Minn.
Ohio Farmer, Cleveland, Ohio.
Our Horticultural Visitor, Kimmurdy, Ill.
Oregon Agriculturist, Portland, Oregon.
Poultry Herald, St. Paul, Minn.
Pacific Coast Fancier's Monthly, San Jose, Calif.
Poultry Culture, Kansas City, Mo.
Park, Cemetery and Landscape Gardening.
Rural New Yorker, New York.
Reliable Poultry Journal, Quincy, Ill.
Rocky Mountain Husbandman, White Sulphur Springs, Mont.
The Republic, St. Louis, Mo.
Strawberry Specialist, Kittrell.
Sentinel, Boulder, Mont.
Successful Farming, Des Moines, Iowa.
Semi-Weekly Tribune, Salt Lake City, Utah.
Sunday Record-Herald, Chicago.
Semi-Weekly Missoulian, Missoula, Mont.
Up-to-Date Farming & Gardening, Indianapolis, Ind.
Weekly Chronicle, San Francisco, Calif.
Western Chronicle.
Western Home Journal, Spokane, Wash.
Western Swine Breeder.
Western News, Libby, Mont.
Wisconsin Agriculturist, Racine, Wis.
Wallace's Farmer, Des Moines, Iowa.
The World, Vancouver, B. C.
The West American Scientist.
The West Virginia Farm Review, Charleston, W. V.
Western Fruit Journal, St. Joseph, Mo.
The Livestock & Dairy Journal, Fresno, Calif.

THE AGRICULTURAL DEPARTMENT.

F. B. LINFIELD, Agriculturist.

For the past year the agricultural department has endeavored to maintain and continue the lines of work previously started, viz.: The field tests with varieties of grains and roots and the feeding tests with steers and sheep.

A co-operative test with the irrigation department was started to determine the effect of various amounts of water on crop growth. It is hoped as time goes on to extend this work and to broaden the field of inquiry.

For the most of the year, perhaps, the energy of the department has been directed towards preparing the way for more extended work in the animal industry line; preparing the way for an increase in the breeding stock upon the farm particularly in cattle, sheep and dairy cows.

It was evident early in the year that to carry out these plans, many old sheds had to be moved and new buildings provided. Plans are being worked out which it is believed will add very much to the efficiency of our livestock work in the next few years.

A great deal of work has also been done in fixing up the farm, making roads through and around it, removing and building fences and laying out the farm so that a systematic rotation could be followed.

Arrangements had also to be made to increase our pasture and hay land to take care of the contemplated increase in breeding stock.

An attempt has been made during the year to devise a series of record books that would give in a permanent form, and easy of reference, a complete record of the work of the department, both for the past and for the future. Considerable yet remains to be done in this direction.

Not as much has been accomplished in some directions during the year as was hoped, because of the increase in the duties of the head of the department in other directions. Expert assistance was very much needed, but in the interim of the Director's absence, it was decided not to make any requests in that direction. With the increase in the livestock work, as planned, however, the department will need an assistant in the work of agronomy for next year. During the year an assistant has been added in the dairy work and Mr. W. J. Elliott, the appointee has rendered very efficient service.

Mr. H. C. Gardiner, student assistant with the poultry, severed his connection with the Station in the Spring and since that time, the poultry has been in direct charge of the agricultural department. As there had been no young stock added to the flock for two years, no attempt was made to do more than maintain the flock for the past season. It is hoped that means can be found to extend and enlarge the plant so that sufficient work will be provided to occupy a man all the time under the direction of the Agriculturist. Such an arrangement would result in greater economy of management and greater efficiency in results.

During the year two bulletins have been prepared by the Department, No. 47 on Sheep Feeding and No. 48 on Steer Feeding. The results of these tests as recorded in the bulletins created quite an interest in sheep feeding in various parts of the state, and was a pertinent illustration of what could be done with Montana fodders when fed to the right kind of stock. It is not necessary to repeat any of the results here as the bulletins are yet available.

The feeding tests with sheep will be continued and the attempt will be made to answer many of the practical difficulties that confront the feeder. We desire to find out the reasons for the failures as well as for the successes. It is only by so doing that the way to avoid the losses can be pointed out.

An important part in both the sheep and steer feeding test was

to determine the relative value of the different kinds of grain as a supplement to the clover hay. This work will have to be repeated for some years before conclusive results can be obtained. The results to date seem to show that a mixture of grains are preferable to any one grain and that a slight change of ration occasionally, will make toward larger and more economic gains.

The tests of different varieties of grains and potatoes have been continued as here-to-fore and the number of varieties have been increased by samples obtained from other states, notably, from the Minnesota and North Dakota stations and from stations in the Canadian northwest and also from the Department of Agriculture, at Washington.

Wheat.—52 varieties of wheat were grown on small plats 1-60 of an acre in area. 20 of these were new varieties most of which did very well. It will take two or three years further testing to be able to determine how many of these varieties are worthy of general distribution. The yield on the small plats ranged from 20 to 72 bushels per acre and averaged 42.6 bushels per acre.

Oats.—There were 30 varieties of oats grown in the experimental plats. Twelve of those were new varieties. The acre yield ranged from 56 bushels to 145 bushels per acre and averaged 103 bushels per acre.

Barley.—Thirty-three varieties of barley were grown and of these 11 varieties were new. The yield per acre ranged from 50 bushels to 97 bushels per acre and averaged 64.1 bushels per acre.

None of the varieties are yet offered for distribution.

THE ROTATION EXPERIMENT.

Rotation Plats.—For six years up to the end of 1903 a six-year rotation experiment had been maintained on the farm. The results of this test were given in the Ninth Annual report. One acre was devoted to each crop in this test. The past season the whole six acres were sown to one crop, viz.: Oats. It was noticed early in the season that there was quite a difference in the growth of the crop on the different acres and the difference was

maintained until the harvest. The difference was so marked it was decided to cut the acre plats separately. The following table gives the results:

Plat	Crop Previous Year. 1902	Yield of Oats 1903		
		Grain		Straw
		lbs.	bus.	lbs.
1	Peas.....	3405	106	3410
2	Wheat.....	1590	49	1250
3	Clover.....	2760	86	2665
4	Barley.....	1335	42	1115
5	Sugar Beets.....	2620	82	2400
6	Oats.....	1952	64	1448

This is a very interesting table and is a very forcible illustration of the advantage of leguminous crop, or of cultivation in giving increased yields of grain. An acre of oats when following a wheat crop of the year before gave 1,590 pounds of grain, but when following a crop of peas yielded 3,405 pounds over twice as much.

Oats following clover gave 2,760 pounds per acre but following barley only gave 1,335 pounds per acre, less than half the yield. Oats following sugar beets, a cultivated crop, yielded 2,620 pounds per acre, but following oats gave 1,952 pounds per acre of grain.

On the average of the whole, when the oats followed a cereal crop, (Wheat, oats and barley) the yield was 4,877 pounds, but when the oats followed a leguminous crop or a cultivated crop, the yield was 8,785, or nearly twice as much.

It is worthy of note also that the yield of straw is in proportion to the grain, in fact the results are a little more favorable to the leguminous crops on the straw yield as from these plats more than twice the weight of straw was obtained as from the other plats. The proportion of straw to grain was noticeably greater after the leguminous crop than after the cereal crop.

Again the crops after the peas and clover gave a larger yield than after the roots. The leguminous crops are the best soil enrichers.

This test affords a most striking illustration of the benefit arising from the use of clover, and one which all farmers should study.

A FERTILIZER LIST.

An interesting supplement to the results from this rotation test was a test of the value of fertilizers. In the spring of 1903 at the suggestion of Dr. Traphagen, four plats of wheat, four of oats and four of barley were set apart for this test. There was 1-60 of an acre in each plat. The first plat of each kind of grain received a dressing of nitrate of soda at the rate of 200 pounds per acre. The nitrate was dissolved and sprinkled on the plat to get it evenly distributed. The next plat received a dressing of Thomas slag, a phosphatic manure. The third plat received a mixture of both fertilizers and on the fourth plat no fertilizer was applied. The following table shows the results:

Plat	Fertilizers	Wheat		Oats		Barley	
		Bus. Per Acre	Straw Per Acre	Bus. Per Acre	Straw Per Acre	Bus. Per Acre	Straw Per Acre
			lbs.		lbs.		lbs.
1	Nitrate of soda.....	84.	6120	79.7	8550	74.6	5150
2	Thomas slag	75.	5100	75.	7500	76.2	4740
3	Thomas slag and nitrate of soda.	83.	5820	82.	9060	81.2	5100
4	No fertilizer.....	69.	.....	75.	8700	53.1	.....

This table shows that the application of a nitrate, (a nitrogenous fertilizer) added materially to the returns from the plats. On the wheat it increases the yield by 14 to 15 bushels per acre. With oats the increase was five to seven bushels per acre and with barley 21 to 28 bushels per acre.

The application of the phosphatic, Thomas slag, shows a slight increase in the wheat plat, and considerable increase on the barley. In fact, the Thomas slag gave larger returns than the nitrate on the barley. On the oats the Thomas slag did not show any particular advantage. A combination of the nitrate and the Thomas slag was no better than the nitrate for the wheat but proved superior for the oats and barley. The results of this test are quite interesting as indicating the needs of our soils. They

do not prove that it would pay to buy these fertilizers but they do prove that fertilization is a benefit to the crop. All of those plats had a light dressing of farm yard manure or perhaps the difference would have been more marked.

The results should be considered in connection with those from the test. above referred to. The leguminous crops, peas and clover, proved better fertilizers than the nitrate and Thomas slag. At least the acre yield of grain was greater, and that, on plats where no farm yard manure had been applied.

Future experience may modify the conclusion but these tests would seem to indicate that in the proper use of alfalfa, clover and peas, the Montana farmer has a fertilizer that will in a large measure, take the place of artificial fertilizers, but he must use one or the other of them if he desires a maximum crop of grain.

CO-OPERATIVE TESTS.

Last March, (1903) the Station sent out the following circular letters to the press and to the farmers of the state.

BOZEMAN, MONTANA, March, 1903.

DEAR SIR:—For the past four years the Experiment Station has grown from 30 to 50 varieties of wheat, 25 to 30 varieties of barley, 25 to 40 varieties of oats and six to eight varieties of potatoes. From these have been selected 15 varieties that are deemed worthy of a trial by the farmers of the state. We therefore offer, free of charge, the following varieties of grain and potatoes as long as the supply may last subject to the conditions given below.

Spring Wheat, 4 varieties:

Opal.

Pringle's Champion.

Chili.

Kubanka (Macaroni).

Oats, 2 varieties:

Swedish Select.

Nameless Beauty.

Barley, 3 varieties:

New Zealand (2-rowed).

White Hulless.

Black Hulless.

Peas, 1 variety:

Golden Vine.

Potatoes, 5 varieties:

Lee's Favorite (medium early).

White Maine (late).

Six Week Market (early).

Early Ohio (early).

Acme (early).

Conditions governing the test:

(1). Twenty pounds of each variety of grain will be sent but not more than four varieties of grain and two of potatoes will be sent to one person.

(2). The person sending for the grain must pay the freight charges.

(3). The results obtained from the growth of the crop must be reported on blanks furnished by the Experiment Station. Said blanks to be returned to the Experiment Station not later than November 1.

Address all communications to,

F. B. LINFELD, Agriculturist,
Montana Experiment Station,
Bozeman, Mont.

For several years the Station had been testing varieties of grain and we desired to get the best of these in the hands of the farmers.

As a result of this letter, 692 requests were received for seed, a number much beyond our expectations.

Seed was sent as long as our supply lasted, but we could send to but 204 persons.

With each lot of seed was sent a blank upon which to report the returns from the crop. To this request for a report we received 93 replies, about 46 per cent of those receiving the samples. A large number of these, however, were incomplete or very general in character.

Samples of seed were sent to 21 counties, viz.: To 68 persons in Cascade; to 5 in Meager; to 4 in Lewis and Clarke; to 12 in Beaverhead; to 25 in Flathead; to 20 in Choteau; to 9 in Missoula; to 4 in Teton; to 7 in Carbon; to 7 in Yellowstone; to 10 in Park; to 4 in Sweetgrass; to 15 in Fergus; to 2 in Madison; to 10 in Rosebud; to 2 in Ravalli; to 2 in Powell; and to 1 in Gallatin.

Analyzing the results by the grains sent out, fairly complete returns were received for one-fifth of the samples of the grains, (wheat, oats and barley) and for a little less than one-half the potato samples. The crops were grown under such a variety of conditions that it would be difficult to draw any definite conclusion. A few general points are, however, worthy of notice.

A large number of reports show that the samples sent were grown without irrigation and some of the largest yields, both of grain and potatoes, were grown without added water. This was noticeably the case in Cascade and Flathead counties. It would appear in several cases but particularly with potatoes that excessive irrigation was a decided drawback both to yield and quality. Light irrigation and thorough cultivation would give more and better potatoes.

In valleys of high altitude, and on the non-irrigated benches, an early maturing crop does best. In the high altitudes danger of frost is avoided and on the dry benches the early crop matures before the land gets too dry.

When the early and later maturing crops are compared on the lower land the general experience is that the early crop is the smaller yielder. It would appear that this can be stated as a very good general rule, that early maturity is at the expense, to a great extent, of crop yield as contrasted with later maturing varieties. Almost without exception the yields and quality of the crop was commented on as equal to, or very much superior to the varieties at present grown by the experimenter, some put them as high as 50 to 100 per cent better.

This report would fully corroborate the conclusions reached on the Station trial grounds as to the value of these new varieties selected for distribuion.

It was evident from many of the replies that much difficulty was experienced in getting the grain cut and thrashed separately from the regular field crops and in getting correct weights of the crop.

Considerable complaint was made about the freight rate on the seeds particularly where two roads were concerned in the haul. From three to five cents per pound freight certainly seems excessive, but the lots were less than 100 pounds in many cases. I do not know as this difficulty can be overcome. However, as these are new varieties and give a start in a crop that may prove very superior to those already grown, the first cost is very small indeed and much below what the grower would have to pay for new varieties from seedsmen in the east, and that for varieties that have not been tested under Montana conditions as the Station seed has been.

In addition to the small lots of seed grain sent out, quite a large quantity of oats and peas were *sold*, and also some wheat, barley and potatoes. All seem to have given excellent satisfaction.



CHEMICAL DEPARTMENT.

F. W. TRAPHAGEN, Chemist.

MONTANA COAL.

In reporting the work of the current year, I also add much miscellaneous data gathered during the ten years in which I have been Chemist of the Station, but not previously published.

This work is not all of direct agricultural interest, yet even in the case of the coal, the farmer is affected to a greater or less extent by the work, for with our limited supply of timber in the eastern portion of the state the finding of a suitable fuel is very important matter.

Fortunately the coal of Montana is so widely distributed and so easily mined, in most cases, that the farmer can easily in a day or two lay in a supply of fuel, generally a good quality of lignite coal, sufficient to last him throughout the year. An explanation of the terms used in reporting the analysis may be necessary. In the ordinary analysis of coals, called the proximate analysis, the coal, after being ground and carefully weighed, is subjected to a temperature slightly above the boiling point of water until it ceases to lose in weight. This loss is reported as moisture. The coal, carefully protected from accession of air, is then heated to red heat for about six minutes and the loss is called volatile and combustible matter, and consists mainly of the gas forming elements of the coal. The remaining material is then heated with free access of air until everything combustible is burnt away, the loss being called fixed carbon, and the incombustible material remaining behind, ash. A coal is valuable as the proportions of fixed carbon volatile and combustible materials are high and the moisture and ash are low.

TABLE No. 1 - Analysis of Coal Constituents.

[illegible]

TABLE No. 1 - Analysis of Coal Constituents—continued.

Date.	Ash Per Cent	Remarks	Description
	16.88	H. P. Cone, Hamilton. Air dried 8mo.	Over which coal field, west fork Bitter Root road, 30 miles south of Hamilton
		Sulphur in soluble sulphate, .027 per cent; total 82.175	Beidger, Carbon county
		Sulphur in soluble sulphate, .0197; total 2.169 per cent	" " "
		Sulphur in soluble sulphate, .03; total 2.187	" " "
Sept. '99	15.925		Irma mine, Carbon county, T. P. McDonald, Bridger
	8.91		Pryor Mountain mine, " "
	8.10		Elk Basin Coal mine, " "
Jan. 31,	21.275		Mountain Side, college shops
Feb. 2	19.285		Bridger, " "
" 8	15.275		Chesnut, " "
" 8	16.87		" chemical building
" 20	20.52		" main
	18.505		" college shops
	19.57		" chemical building
	19.57		" main
May 5, '0	20.475	Sample of carload, car No. 53805	Trail Creek, Mountain House, C. W. Hoffman
	14.725	" " " No. 57508	" " " "
	16.85	" " " No. 51503	" " " "
		Sulphur in coal, .83 per cent	Blacksmi
	16.30		Chesnut
June 22	2.69	8 1/2 ft. thick, no dirt, even ash	Southern part big horn basin, Wyo., T. P. McDonald
	12.53	5 1/2 ft. ;	Western " "
	6.09	5 ft. 1 c	Near Basin City, Wyoming " "
	7.76	Dark grey ash	Sage Creek, near Frost, Wyoming " "
	8.415	11 ft. thick, sampled on outcrop dark grey ash	Paint Creek, eastern side B. H. basin, " "
Jul. 12	14.125	3 ft. thick, dark grey ash	Sun River, northern Montana
26	6.65		Trail Creek, C. W. Hoffman
26	1.475	Lignite, friable coke, reddish ash	Heaver Creek, Homer Squyer, Wilbaur
	24.25	Coke 65.50 per cent; ash in coke 37.02 per cent	Taylor's Fork, Ernest Hellman
	20.475		Chesnut coal, J. C. McCarthy
	8.225	Reddish yellow ash	Musselshell, N. Carlisle Titus
Oct. 3	8.04		Anderson Mine, B. H. Basin No. 1, T. P. McDonald
	8.22	Almost white ash	Big Horn basin, " "
	41.735	Grey ash	Gallatin basin, west fork, Gary Bros.
Dec. 6	6.15		Carbon Co., Mont., No. 1, T. P. McDonald
	5.245		Gooseberry coal field, near B. & M. Ry., Wyo. No. 2, T. P. McDonald

TABLE No. 1 Analysis of Coal Constituents—continued.

Date	Lab. No.	Moisture Per Cent	Vol. and Orig. Material	Fixed Carbon	Ash Per Cent	Remarks	Wyo., No. 3.
Dec. 6	1681	9.135	30 12	56.835	3.80		
Jan. 14, '01	1688	4.105	36 13	53.78	5.955	Reddish yellow ash, lignite.	
Feb. 4	1704	6.70	30 50	48.25	14.35	" ash	cook
20	1709	7.575	35 20	51.10	6.125	" coke 58.6 ash in coke 17.91.	
	1747	3.775	37 623	48.10	10.50	Coke 61.98; ash in coke 15.3	
	1748	1.67	34 87	54.18	9.78	" 60.57; " 6.98	
	1749	3.77	35 86	56.34	4.28	" 57.08; reddish ash	
25	1750	6	36 94	54.58	2.50	" Ash greenish.	R. 59 E., 2 M.
26	1751	9.30	33 50	49.265	7.935	" reddish, 3 in. clay parting; gen. samp.	3. 00 E., 4 M.
Mar. 16	1752	28.735	33 025	38.85	4.39	" red, picked sample.	3. 00 E., 4 M.
	1753	27.925	31 95	29.25	9.875	" reddish.	r. Mont.
	1754	28.30	33 05	36.80	1.85	" yellow Bi.	dge mont cement used
Apr. 24	1755	0.25	825	86.375	12.975	" Ash grey	
May 1	1756	35	1 10	81.60	16.95	" Ash reddish	
15	1760	3.9	36 775	49.635	9.69	" Ash brown	
30	1761	4.925	34 07	53.875	7.13	" reddish	
	1762	9.575	32 979	41.78	15.675	" dark grey	
Jul. 15	1771	12.325	37 905	40.965	9.405	" light grey	
	1772	6.655	34 969	18.96	9.405	" reddish	
	1773	3.94	29 82	49.54	17.70	" light grey	
	1776	3.88	32 05	52.785	11.785	" white	
Aug. 29	1779	13.9	29 48	50.53	6.08	" yellow Bi.	
	1780	14.47	35 95	43.27	7.21	" dark grey	
	1784	5.98	35 25	50.0	8.67	" light grey.	
	1787	4.5	37 775	49.80	7.925	" reddish b.	
	1788	11.525	34 225	42.325	11.925	" light grey.	
	1789	11.90	31 75	39.875	16.575	" light buff.	
	1790	11.34	31 60	42.20	14.86	" dark grey	
	1811	11.95	33 55	46.375	8.125	" light grey	
	1792	11.25	25 35	51.825	8.575	" white	
	1793	9.78	27 90	47.35	14.97	" yellow Bi.	
	1794	10.56	31 50	50.95	6.99	" dark grey	
	1795	10.38	31 90	45.60	12.12	" light grey.	
	1796	11.91	35 40	58.50	4.19	" reddish b.	
	1797	11.90	33 25	50.35	3.50	" light grey.	
	1798	15.87	38 375	47.275	3.48	" light buff.	

[No. 6 Jones' seam, Thermopolis, Wyo.; bottled sample]

TABLE No. 1.—Analysis of Coal Constituents—*continued*

Analysis of Clays. -- The following analysis are offered as showing the characteristics possessed by Montana clays.

*The silica in these two analysis is not pure silica but the silicious residue obtained by solution of the sandstones in water. Results under a950 and a951 give more reliable data.

Date.	No.	Description.	SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	FeO (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	Fe ₂ O ₃ (%)	FeO (%)	K ₂ O	Na ₂ O	20)
.....	E132	Clay--Robt. King's gulch, 3 miles N. E. of Bozeman	13.48	51.00	4.57	17.69	...	8.49	2.80	...	...	...	...
.....	133	" Brick yard near creek south of Bozeman	13.77	52.60	4.57	10.23	...	13.43	2.71	...	...	...	...
.....	134	" Near old powder house 2 miles N. W. of Bozeman	8.77	51.70	5.53	23.13	...	6.18	3.49	...	...	...	...
.....	135	" East side Church St. near old electric plant	7.50	58.32	2.66	21.24	...	1.73	1.59	...	...	...	...
.....	136	" Brick yard near race track	8.49	56.45	3.76	18.30	...	8.09	2.79	...	...	...	...
.....	137	" Sample of C. M. Thorpe, No. 1	4.36	65.37	...	...	20.60	3.90	1.62	...	...	...	...
.....	138	" " " 2	7.01	59.34	...	...	27.65	1.93	2.30	...	...	...	...
.....	139	" " " 3	6.49	59.46	...	...	23.70	1.80	1.90	...	...	...	...
.....	140	" Daniel Maxey, Bridger canyon	6.80	47.20	4.74	29.21	...	2.83	3.05	...	...	...	...
.....	141	" J. M. Hamilton, Missoula	5.22	61.30	3.80	21.68	...	1.81	1.11	...	...	...	...
.....	142	" West Gallatin ditch	5.25	39.80	2.13	15.28	...	25.98	4.77	...	...	...	...
1896	143	Marl from excavations for granary, Experiment Station .....	...	54.30	...	...	16.62	11.16	2.93	...	...	...	...
Jan. 21	144	Fire'clay--Mr. I. Aldritt, Bear gulch	H. 4.04	66.86	FeO 1.72	18.26	...	1.40	1.77	0.15	0.11	...	...
May 18	180	Limestone analyzed for Att. General Haskell	C. 4.40	...	...	...	...	89.52	39.154	...	...	...	42.85
Oct. 3	557	Clay from Phillipsburg .....	...	1.02	...	...	29.71	83	...	...	...	...	...
.....	588	" " T. A. Marlow, Helena, No. 1	H. 8.05	52.62	...	...	...	71	43	60	...	...	...
.....	589	" " " 2	C. 1.12	...	...	...	...	80	36	2.20	...	...	...
.....	1010	"Cement" A. W. Miles, Livingston	H. 2.18	72.85	78	17.50	...	...	...	...	...	...	...
.....	1011	Feldspar of corundum matrix	C. 2.63	19.46	3.09	8.37	...	48.07	92	...	...	...	...
.....	1012	Alabama Kaolin, Fort Payne, Ala .....	...	18.52	...	...	...	...	...	...	...	...	...
.....	*950	Ulm sandstone for Bell & Kent. Helena	6.74	40.47	...	38.31	...	...	...	...	...	...	...
.....	*951	Columbus sandstone for Bell & Kent, Helena	13.70	96.01	1.01	.09	...	.16	...	...	...	...	...
.....	952	Clay, Bridger, Mont., W. Cooper .....	...	84.66	1.52	1.12	...	.71	...	...	...	...	...
.....	a950	Ulm sandstone	2.03	60.96	...	25.03	...	1.36	56	...	...	...	...
.....	a951	Columbus sandstone	7.15	90.24	.758	5.38	...	.51	.06	...	...	...	...
.....			.51	78.74	1.52	12.26	...	.72	.10	...	...	...	...

ANALYSIS OF APPLE TWIGS.

Several years ago an examination of the twigs of apple trees was made to learn something concerning the reserve carbohydrates contained during the dormant season. These twigs were removed late in November after the winter was well established and when sap movements had certainly ceased.

The large amount of soluble and molt soluble carbohydrates found are interesting.

It was planned to continue this work and to broaden the scope of the analytical work in an endeavor to discover, if possible, some relation between chemical composition and relative hardness, but the work was necessarily discontinued because of pressure of routine work in College and Station. The results are given here and it is hoped that someone may find time to continue the investigation.

Analysis of Twigs of Apple Trees.—Sample Taken November 1, 1899.
Analyzed January 5, 1900.

Description.			Lab. No.	Moist-ure Per Cent	Water sol. figured to sucrose	Malt sol. figured to starch	HOL. sol. figured to starch	Nitrogen
New growth	"	No. 44-12 Apple.....	1040	6.22	4.19	2.09	12.50	.61
Old	"	" " " "	1041	6.25	3.18	3.32	14.77	.54
New	"	" 66 Anisette".....	1042	6.67	4.06	3.58	14.32	.39
Old	"	" " " "	1043	6.70	3.22	3.32	15.03	.58
New	"	" 270 Thompson No. 10"....	1044	6.23	4.57	3.80	15.47	.30
Old	"	" " " " " "	1045	6.54	3.60	4.06	15.12	.55
New	"	" 334 Longfield".....	1046	6.56	6.14	....	15.03	...
Old	"	" " " "	1047	6.16	4.06	....	14.60	...
New	"	" 437 Yellow Transparent".	1048	6.21	5.86	3.67	15.03	...
Old	"	" " " " " "	1049	6.50	4.06	3.14	15.18	...
New	"	" 363 Duchess".....	1050	6.41	5.82	3.50	14.77	...
Old	"	" " " "	1051	6.86	3.22	3.14	15.18	...
New	"	" 335 Wealthy".....	1052	5.64	3.83	2.84	15.38	...
Old	"	" " " "	1053	6.06	3.26	3.23	16.08	...
New	"	" 395 Transcendent".....	1054	5.62	5.94	3.14	14.68	.28
Old	"	" " " "	1055	5.78	4.29	2.53	15.38	.54
New	"	" 278 Red Astrachan".....	1056	5.90	6.37	2.01	.....	.5
Old	"	" " " " " "	1057	5.46	5.22	1.14	.....	.48

ANALYSIS OF WHEAT GROWN UNDER IRRIGATION.

The accompanying analysis of wheat were made for the purpose of determining the influence of irrigation upon the composition of wheat.

In each case the seed of the first year (1899) was that obtained from outside sources, that is, from some other source than our own Station.

The seed of the second year was obtained from the crop of the previous year, and in like manner the seed sown the third year was obtained from the second year's crop.

Contrary to the generally accepted idea, the results obtained show that under conditions of ordinarily careful irrigation the protein content does not become appreciably reduced, on the other hand there is a fair basis for advancing the opposite opinion, that the protein content may be actually increased under careful irrigation. It appears, moreover, tolerably certain that the change is no greater than would take place under continued cropping on the same variety in the same locality where irrigation was not practiced.

What the results would be under excessive irrigation we are not prepared to state.

More work in this line should be carried on before final statements are made, and the work of the chemist should be supplanted by very careful measurements of the actual water received by each crop.

Wheat Analysis.

Year Grown	Lab. No.	Name	Ash	Moisture	Nitrogen	Crude Protein	Nitrogen free Extract	Ether Extract	Crude Fiber
1899	2207	McKissick's Fife.....	2.10	9.88	1.94	12.125	71.495	2.09	2.31
1900	2208	" ".....	2.25	7.18	1.95	12.187	73.803	2.11	2.47
1901	2209	" ".....	2.14	8.25	2.08	13.	72.07	2.07	2.47
1899	2210	Glyndon 650.....	2.14	10.23	1.87	11.687	71.203	2.40	2.34
1900	2211	" ".....	2.40	7.46	2.28	14.25	71.41	2.09	2.39
1901	2212	" ".....	2.30	8.59	2.35	14.687	69.83	2.03	2.56
1899	2213	No. XB.....	2.39	9.09	1.45	10.06	74.09	1.76	2.61
1900	2214	" ".....	2.07	7.41	2.15	13.437	72.64	1.92	2.52
1901	2215	" ".....	2.39	7.66	2.	12.50	72.72	1.84	2.89
1899	2216	Glyndon 692.....	2.90	8.85	2.18	13.625	70.025	1.98	2.62
1900	2217	" ".....	2.97	7.17	2.81	17.56	67.80	1.88	2.62
1901	2218	" ".....	3.30	6.14	1.79	11.20	74.55	2.11	2.70
1899	2219	Junket.....	2.12	9.01	1.91	11.937	72.17	2.20	2.56
1900	2220	".....	2.02	7.23	1.94	12.125	74.34	2.15	2.13
1901	2221	".....	2.04	7.70	2.15	13.437	71.95	2.23	2.65
1899	2222	Glyndon E661.....	2.16	10.22	2.10	13.125	69.69	2.38	2.43
1900	2223	" ".....	2.22	7.84	1.97	12.31	72.83	2.16	2.64
1901	2224	" ".....	2.68	8.55	2.21	13.81	71.30	2.12	2.54
1899	2225	" 675.....	2.17	10.05	2.05	12.86	69.97	2.19	2.76
1900	2226	" ".....	2.58	8.	2.33	14.56	69.96	2.14	2.76
1901	2227	" ".....	2.42	9.10	2.13	13.31	70.69	2.01	2.47
1899	2228	Club.....	2.40	10.22	1.64	10.25	72.33	2.26	2.51
1900	2229	".....	1.88	7.83	1.98	12.37	73.88	1.44	2.60
1901	2230	".....	2.48	8.29	2.04	12.75	72.23	1.42	2.83
1899	2231	Russian Orig. Seed 2955.....	1.63	7.88	2.45	15.31	70.28	2.03	2.87
1900	2232	" " " ".....	2.46	7.49	2.06	12.87	72.89	1.88	2.41
1899	2234	Gold Drop.....	1.23	7.42	2.17	13.56	72.86	2.16	2.77
1900	2235	" ".....	1.08	9.76	2.46	15.37	69.16	1.60	3.03
1901	2236	" ".....	2.20	7.43	2.22	13.87	71.15	3.08	2.89
1899	2237	Glyndon E963.....	1.35	9.84	2.06	12.87	70.66	2.83	2.45
1900	2238	" ".....	1.16	7.64	2.30	14.37	71.53	2.74	2.56
1901	2239	" ".....	1.18	8.37	2.02	12.62	72.39	2.86	2.58
1899	2240	" E676.....	1.18	7.86	1.96	12.25	73.17	2.85	2.69
1900	2241	" 676.....	1.19	5.63	2.39	14.93	72.89	2.75	2.61
1901	2242	" ".....	1.21	6.01	2.22	13.87	73.77	2.41	2.73

In reviewing the work of the past years, the importance of having more assistance in the chemical laboratory is a matter that deserves careful consideration.

The field is almost a virgin one and there are many lines of investigation that should be undertaken and carried out. To do this work, however, would require a marked increase in the chemical staff, the additional expense would certainly be justified by the more valuable contributions from the laboratory that could thus

be made. It is only in this way that original investigations of marked merit can be carried on, for under previously existing conditions there was but little time for any work but the regular routine analysis.

The following miscellaneous results are added without comment:

Constituents of Grains, Flours, Etc.

Date	No.	Description	Ash	Moisture Per Cent	Nitrogen Per Cent	Crude Protein w. x 6.25	N-free Extract	Ether Extract	Crude Fiber
Mar. 18, '99	953	Barley, 6-rowed Kalispell Malting & Brewing Co.....	2.77	7.79	1.52	9.5	72.82	2.17	4.95
" " "	954	Barley, 2-rowed, Kalispell Malting & Brewing Co.....	2.66	7.49	1.43	9.04	74.79	2.02	4.
" " "	955	Alsike, sheep feeding experiment, Prof. Shaw	9.72	6.05	2.08	13.	38.71	3.07	29.45
" " "	956	Alfalfa, sheep feeding experiment, Prof. Shaw... ..	7.55	5.09	1.977	12.37	39.82	4.07	31.10
" " "	957	Canada Field Pea, straw experiment, Prof Shaw.....	7.35	5.33	1.47	9.19	39.84	3.59	34.70
" " "	958	Red Clover experiment, Prof. Shaw..							
Apr. 10, '01	1757	Flour No. 1, Thompson Bros., Livingston.....	8.69	5.16	1.976	12.37	45.84	5.29	22.65
" " "	1758	Flour No. 2, Thompson Bros, Livingston .....	.....	9.95	2.25	14.06	.....	.....	.....
" " "	1759	Flour No 3, Thompson Bros., Livingston .....	.....	8.85	2.33	14.56	.....	.....	.....
		.....	.....	7.90	1.75	10.94	.....	.....	.....

ENTOMOLOGICAL DEPARTMENT.

R. A. COOLEY, Entomologist.

GENERAL STATEMENT.

The work of this department, outside of the publication of the results of the investigations and attendance upon public meetings such as Farmers' Institutes and Horticultural Conventions, is naturally divided into two parts, (1) the routine work of the office and (2) the general and special investigations in various parts of the state.

Because of the gradually widening scope of our work and because of the increasing demands on the office from citizens of the state, the routine work is increasing every year. This work while it produces little external appearance, is of great importance. It includes the equipping and maintaining of the laboratory and library; the study of life histories of insects that are sent in or that are found doing injury in the state; the identification of specimens; library research; pinning and mounting of specimens; working over collections; correspondence; and the general executive work of keeping the records and accounts of the department.

The general and special investigation work in the various parts of the state comprises that part of the department's activities that extends its usefulness and links the theoretical and practical sides of entomology. This division includes the general survey of the various branches of agriculture from an entomological standpoint and the special study of particular problems. Among these problems are the control of the various pests of the farm, orchard, garden, lawn and household; tests of insecticides, etc.

This department has attempted to promote all sides of its work, indeed has been required to do something in all the various lines, but in no line has it been able to produce the results desired. The head of the department has been without regular assistance and has been much interrupted by the Farmers' Institute and other public work.

It is earnestly hoped that our state legislators may be moved to afford us a more generous financial support, thereby enabling us to conduct our work with greater system and effectiveness.

The eighth (last) legislative assembly passed an act whereby the Entomologist of the Station is appointed State Entomologist. The act also appropriates \$300 to pay his traveling expenses, and requires that "whenever it shall become known to the State Entomologist that an outbreak of an insect has occurred in any part of the state he shall go to the scene of the outbreak, determine its extent and seriousness and publish or make public demonstration of the best means to be employed in destroying the insects."

It is believed that this act will have the effect of greatly increasing the usefulness of the entomological department of the Experiment Station.

During the past year we have followed in general the work outlined in my last annual report. Particular attention has been given to grasshoppers, to fruit insects and to the enlarging of our insect collections.

During the coming year it is our intention to continue with our investigations of grasshoppers, trying to learn the cause for their gradual or sudden disappearance which we confidently expect will occur. Such information will be a valuable acquisition to the notes of this department for it is not unlikely that in future years we may have a recurrence of the grasshopper invasion. We shall also continue to study the insects injuriously affecting fruits. Some special studies will be made on the codling moth, the bud moth and the strawberry root weevil.

We purpose also to attempt to exterminate an isolated colony of the codling moth in an orchard at the head of Flathead Lake, by picking off the fruit, taking care to do so at just the right time. In order to determine the right time we shall make a close study of the habits of the moth.

During the coming year the department will also devote a considerable part of its energies to the collecting of insects in all parts of the state. In order to put our work on the surest and most economical basis we feel that we must give particular attention to the making and arranging of collections.

Arrangement has already been made for the setting aside of a piece of ground close at hand to the site selected for the proposed biology building. We intend to plant a few fruit trees, currant bushes, strawberry plants and other fruits as well as some of the more important shrubs and shade trees, all of which will be for experimental purposes connected with entomological investigations.

APHIDIDS, OR PLANT LICE.

Plant lice are small soft bodied insects which occur commonly on foliage or tender bark of plant. Their food is the sap which they extract through a beak attached to the under side of the head. They are of great interest both from an economic and from a scientific standpoint. In the classification of the insect world they are placed in the order *Hemiptera*, or true bugs, and to that subdivision of the order known as *Homoptera* because of the fact that their wings are of uniform texture throughout.

A large number of plant lice, including many species of economic significance, are to be found in Montana. Many of our native shrubs and herbs are affected by them and on our cultivated plants they appear to find congenial surroundings.

Their objectionable presence is familiar to almost everyone. The honey dew secreted by them drops from the foliage of shade trees, smearing the side walks and furnishing an attraction for flies, wasps, ants and bees which are an annoyance about residences.

Some species are among the most injurious and least easily controlled insects with which we have to contend.

STRUCTURE OF PLANT LICE.

The body of a plant louse, in common with other insects is divided into a head, a thorax and an abdomen, which parts are easily distinguished in some insects, while in others they are so indistinctly separated as to make the body appear to be made up of

one continuous piece. In plant lice, particularly in the early stages, the body seems to be not plainly divided. In general form it is oval or pear shaped.

The Head.—The head of plant lice is the front portion of the body and is small compared to the other parts. The more noticeable appendages of the head are the eyes, antennae and beak. The eyes are always present except in a few root inhabiting species. They are compound, hemispherical and are situated in the sides of the head. The winged forms also have three ocelli or simple eyes arranged in a triangle.

The antennae are thread shaped, jointed appendages attached in front of the eyes, and are much used in classification on account of the excellent distinguishing characters they bear. The number of segments varies from three to seven. In many plant lice certain joints are provided with sense pores often called sensoria. It is held by entomologists that these sense pits are connected with the sense of smell or hearing or both. When the beak is not in use it is drawn up against the body and lies extended between the legs. It is made up of three fleshy joints or segments which are channelled on the inner surface for the reception of four very fine piercers or *setae*. These *setae* are the parts that enter the tissues of the plants when the louse is feeding. They are sometimes very much elongated, so much so that when not in use they are drawn back into a special tubular receptacle which extends into the abdomen.

The Thorax.—The second of the three grand divisions of the body is the thorax. To it are attached the two pairs of wings, (when present) and the three pairs of legs.

The wings are four in number, the front pair being larger than the hind. They are very thin and delicate and are usually almost transparent, but are sometimes clouded in spots. The veins are few in number but are of great service in the separation into sub-families. When at rest the wings are usually held roof-like over the back but in some cases they lie horizontally upon the abdomen. The legs are six in number. Each leg is divided into a number of parts which have received names. The first joint, the coxa, unites the leg to the thorax. Then follow two long segments, the femur and tibia which make up the greater proportion of the

leg, and the tibia to which is attached the two jointed tarsus. The last joint of the tarsus is furnished with two hooked claws.

The Abdomen.—The series of primary segments following the thorax is called the abdomen. Extending down each side of the abdomen may often be seen a ridge or fold of flesh giving the side of the abdomen a definite margin.

The sixth abdominal segment has on the dorsal side a pair of openings which are usually raised more or less above the surface on prominences or at the end of tubes which project upward and backward from the body. These are called honey tubes. It is not clearly understood of what use these are to the plant lice. They appear to be the external opening of secreting organs for they give off a sweet liquid that is sought and eaten by ants.

At the posterior extremity of the body is usually a process known as the style. The size, form etc, of the style furnish good characters in classification..

LIFE HISTORY.

While probably no two species of plant lice are precisely alike in the life cycle all have, in a general way, the same life history. These lice are a striking example of parthenogenetic reproduction or reproduction from virgins. For the most part the young are born alive without first hatching from an egg. The egg stage is most commonly the one in which lice pass the winter. These eggs hatch in the spring, producing the first generation known as the stem mothers. These lice, which may appear early in the season before the cold spring storms have all passed, are at first very small but they at once commence to feed on the sap of the host plant and soon have reached full size and maturity when they may be wingless or winged. These stem mothers give birth to young, (second generation) which at once begin feeding and when mature, in their turn produce young which constitute the third generation. Thus one generation after another follow until the end of the season. In some species a part of the lice in these generations, which are composed entirely of females, acquire wings and fly to the other plants of the same kind or which are equally suitable as food. In this way the supply of food is increased. At the end of the season a generation of perfect or sexed lice appears which

copulate in the usual way, the females depositing the eggs which are to survive the winter. The favorite host plants of some species do not last all summer, and when this is the case the life history may be less simple. The lice may all rise and migrate to some entirely different host plant, not returning to the first host plant until the fall or the next spring. Under such circumstances, it is very difficult to unravel the life history of a species.

I have for a number of years noted that in the early fall after the first frosts, the cabbage aphid rises into the air in great numbers during the hot sunlit hours of the day and disappears in the air. They doubtless go to some other plant or plants on which they deposit their eggs and on which they feed during the first part of the summer. I have also repeatedly observed that in making their appearance in a new field of cabbage, turnips or of other similar plant, they come first in small numbers and that their coming is rather late in the season, in Montana. So far as is known to me nobody has yet observed what the alternate food plant of this aphid is.

THE ELM GALL-LOUSE.

Schizoneura americana Riley.

Experience is teaching us that in many parts of Montana the elm may be grown successfully. Great Falls and Missoula easily lead the state in the number of these trees they have, but the elm gall-louse has in some cases become a severe pest.

This aphid occurs on the under side of the leaves of white elm (*Ulmus americana*) causing them to curl and blister. The blistered parts lose their natural green color and turn whitish or yellowish. Later in the season these deformed leaves or pseudo-galls may become so divitalized as to turn brown and die. They often, if not always, fail to drop to the ground with the unaffected leaves and remain as unsightly objects on the trees during the winter. In cases of slight infestation only here and there a leaf may be affected, while in severe cases every leaf at the end of the branch may be injured. Within the curled leaf are, beside the colony of living lice, the cast skins of the lice and a quantity of sweet liquid secreted by the insects gathered in globules, each globule being coated over with the pulverulent secretion from the

bodies of the lice. One may often find various other insects in the same leaf folds, some merely taking advantage of the retreat and others feeding predaceously on lice or eating the sweet liquid.

Altogether they are a decidedly obnoxious pest. Not only do they distinctly injure the trees but they disfigure them as well and furnish an attraction for ants, flies and other insects which visit them for the sweet liquid.

LIFE HISTORY.

With his usual accuracy, Dr. Riley worked out the life history of this insect and published it in the Hayden Bulletin, U. S. Geol. Survey, Vol. 5, p. 4. Much of what follows is from his pen. I have, however, verified much of it for Montana but have not reviewed his work on the number of generations. Our work on the life history in Montana was conducted at Missoula in the summer of 1902.

The eggs are deposited in the crevices of the bark and are minute yellowish objects. In this stage the insect passes the winter. In the spring of the year as the leaf buds are opening the lice hatch from the eggs and crawl to the young tender leaves, nestling closely into the crevices. The puncturing of the tender leaves with the rostral setae has the effect of causing an abnormal growth of the cells thereby producing the pseudo-galls. These first lice of the season, or stem mothers, reach maturity in about two weeks and are then about one-sixth of an inch long. By the time the leaves have reached about one-fourth full size the galls are easily seen and by uncurling a leaf one may find a stem mother and her family of young around her.

The young of these stem mothers are much like the parents, but their young, the third generation, when they become mature, have fully developed wings. Dr. Riley found that these winged lice produced about a dozen eggs, or, more correctly, pseudova, for the young are so nearly hatched when the eggs are produced that the young are almost born alive. The fourth and fifth generations follow and are much like the second. The sixth generation, again, has wings but the lice are dark red or brown. Thus far all the individuals have been females, but the seventh generation, produced by the sixth, is composed of perfectly sexed individuals,

which mate. The females each produce one impregnated egg which is left in a crevice of the bark.

There is little danger that this insect or its work will be confused with any other. The only other species at all liable to be mistaken for it is one known as the Cock's Comb Gall-louse. The galls of the latter species are very characteristic, being always on the upper side of the leaves and as their name indicates, resembling a cock's comb. The galls are elongated hollow excrescences which open on the under side of the leaves in elongated slits.

The winged adults of the elm gall-louse have the head and thorax black and the abdomen reddish brown. The honey tubes hardly appear above the surface of the body. A white powdery substance is always strongly apparent on the bodies of the lice within the galls.

BOX-ELDER PLANT LOUSE.

Chaitophorus negundinis Thom.

Box elders are a favorite shade and ornamental tree in the cities of Montana but they are often attacked by the box elder plant-louse, which in some seasons becomes so abundant as to threaten their health.

LIFE HISTORY.

Like many other aphids the life history of this species is imperfectly known. The winter is passed in the egg stage, the eggs hatch early in the spring and by the time the first leaves appear the first generation of lice, which develop into the stem mothers, are abroad. They multiply rapidly and sometimes completely cover the under side of the leaves. We have known trees at Helena, Mont., to be almost completely deprived of their foliage because of the presence of this insect upon the leaves, so devitalizing them by extracting the sap as to cause them to drop to the ground. During the summer, winged individuals appear which fly to other trees thus extending the range of feeding grounds. The eggs are produced in the fall of the year in the crevices of the bark and between the buds and twigs.

The presence of these insects is objectionable not alone because of the lice themselves, but because of the ants and other insects attendant upon them for the sake of the sweets they produce.

The species is attacked by many parasites and predaceous enemies. Probably the most beneficial enemy from man's standpoint is the five-spotted lady-bug (*Hippodamia 5-signata*).

THE WOOLLY APHIS OF THE APPLE.

Schizoneura lanigera Hausm.

In some parts of the United States the woolly aphis is among the more important pests of the apple. In Montana, however, though to the writer's knowledge it has occurred in the same place for about six years, it has not so far as we are informed, been in the least injurious. However, it may at any time appear in injurious numbers and the fruit grower should inform himself of its appearance and habits so as to be able to defend himself against its inroads. It occurs in the western fruit growing sections of the state and the Yellowstone valley.

DISTRIBUTION.

There is considerable doubt as to whether the woolly aphis is of European or American origin and the question will probably never be settled. It is widely distributed throughout the world. Its means of distribution over long distances is on the roots of plants sent as nursery stock.

LIFE HISTORY AND NATURE OF ATTACK.

The woolly aphis exists in two forms, one above the ground, on the water sprouts, in wounds such as those caused by the removal of branches and limbs and in the open places caused by the splitting of the bark from sun-scald, and another found only on the roots. The aerial form appears as masses of white flocculent matter which when broken apart reveal the dark colored bodies of the insects. The flocculent or woolly matter is simply a secretion from the bodies. The presence of this form of the insect sometimes gives a tree a distinct whitish appearance on the affected parts. We should here call attention to the fact that there are various other aphids which attack other trees beside the apple and are covered by a similar flocculent growth from their backs.

The root form of the insect is the one which is responsible for much of the greater part of the injury caused by the species. Its attack on the roots induces irregular enlargements known as galls

and in the cracks and in these galls the bluish-white flocculent masses are found.

There is another distinct disease of apple trees in Montana which produces a somewhat similar abnormal growth on the roots. This disease is known as crown gall. In Montana the crown gall disease appears to be of much more importance than the woolly aphis and the fruit grower should be able to distinguish between the two troubles. The crown gall disease primarily affects the crown or upper part of the root, where it produces an irregular excrescence of variable size. Other galls may be produced on the finer deeper roots, but they are usually of a more spongy texture and of more elongated form than those produced by this insect.

The attacks of woolly aphis are much more serious on nursery stock and in newly planted orchards than on older trees. A moderately infested tree may show no serious effects, but when the lice are very abundant on the roots a tree assumes a sickly appearance and fails to make the normal growth. Continuation of such an attack results in the death of the tree.

In the fall of the year winged individuals, very dark in color, with more or less cotton secretion on their backs, make their appearance and are the means of the extension of colony of insects.

THE CURRANT APHIS.

Myzus ribis Linn.

This aphis first becomes noticeable when the new currant leaves have reached nearly full size. The lice live on the under side of the leaves causing them to become blistered or curled. The green color is often replaced by a whitish or redish tinge. The insects themselves are yellowish green in color. The winged individuals have the head and thorax shining black with the abdomen pale green or yellowish green and a quadrate patch of black on the top of the abdomen.

LIFE HISTORY.

The insects that appear early in the season are without wings but later in the summer winged individuals occur and fly to other bushes. It is stated that the aphis abandons the currant entirely

in the summer migrating to some other plant, and that the last brood of the season returns to the currant, the females depositing the eggs on the stems. These eggs hatch in the following spring into stem mothers which cause the blistering of the leaves.

THE APPLE-LEAF APHIS.

Aphis pomi DeG.

Bulletin 51 of this Experiment Station contains an account of this insect in Montana and remedies are given. We therefore omit a detailed account of it from this report since Bulletin 51 is available to all who request it.

THE CABBAGE APHIS.

Aphis brassicae Linn.

The cabbage aphis is the most abundant and destructive insect affecting the cabbage in Montana. Cabbage, turnip, cauliflower, rutabaga, radish, rape and various other plants in the same natural family, (Cruciferae) are its host-plants. Its presence usually first becomes noticeable in the middle to the latter part of the summer and from then on it becomes increasingly abundant until cold weather approaches. It attacks the leaves and the stems and when abundant causes them to wilt until sometimes they lie flat on the ground, and if the attack continues eventually die.

They first appear only in restricted spots in the field and gradually spread from these spots until the whole field is involved.

The lice are about one-twelfth of an inch in length and of a grayish green color, the grayish tinge being due to a powdery substance covering the body. There is a series of black spots on each side of the back, becoming larger in size towards the tip of the abdomen. The antennae are green with black tips and the legs are black. The winged individuals have the thorax black with the abdomen of a dirty-green or yellowish-green color with the same pulverulent covering. The honey tubes are short and small, not more than the length of the tarsae and more or less dusky. When disturbed the lice move very slowly if at all.

DISTRIBUTION.

The cabbage aphis is a native of Europe, but has been known

in this country for many years, having been recorded by Dr. Fitch in the year 1791. It is now widely distributed in the United States and Canada extending even into the more southern states.

LIFE HISTORY.

So far as I am aware the life history of this species has never been worked out thoroughly. Dr. Smith states that in New Jersey the lice appear in great numbers early in the season. Our experience in this state however, plainly indicates that under our conditions the lice do not appear in force until rather late in the season. I have watched for the first appearance of the lice for a number of years and have noticed that the first arrivals come singly and settle on the under side of the leaves. A few days later a colony of young may be found around these lice and from then on they increase in number rapidly and as winged individuals appear they spread to other plants near by. It is very noticeable that only isolated spots in a field of cabbages or turnips become first affected. In the summer of 1902 I watched with interest the inroads of this pest upon a field of turnips. The isolated patches of infested plants gradually increased in size until they united, eventually involving the entire field. The same thing has been observed less markedly on other occasions in Montana. In early October, after the first frosts, during the quiet warm hours of the afternoon the lice arose into the air in great numbers and flew away. There can be little doubt that they were migrating to a food plant more appropriate for winter quarters. The writer has found the eggs in great abundance at Bozeman on old cabbage and cauliflower stumps that were left in the field over winter. From the many hundreds of eggs, however, that were observed, only one stem mother was seen to have hatched. This single louse wandered about on the lifeless stump and finally perished.

The few facts we have in the life history of this species seem to indicate that in Montana there is an intermediate host plant on which the lice spend the winter in the egg state and feed during the early summer and from which they later migrate to cabbage and similar plants.

THE WHEAT-PLANT LOUSE.

Nectarophora granaria Kirby.

The wheat or grain aphid is well known to growers of cereals in Montana. It often occurs in great numbers and at harvest time sometimes interferes with the cutting of the grain by clogging up the rollers of the aprons.

Growers are in doubt as to whether or not the presence of the insect is a serious injury to the grain crop. It is generally held that the chief damage done by this species is that of causing the grains to shrink, thus lessening the value of the crop.

DISTRIBUTION.

Like so many of our destructive insects the grain aphid is of European origin. In the United States it occurs generally distributed from the Atlantic to the Pacific.

LIFE HISTORY.

Though various people have attempted to work out the life history of this species we are thus far only partly informed on this subject. The lice appear on the young grain early in the season, having spent the winter on some unknown plant. As the grain grows they pass to other parts of the plant and as soon as the heads are formed crawl in among the kernels where they remain until the grain is ripe. As winter approaches the insects crawl down along the stem and get under ground on the roots. These root forms are wingless and continue their work under the snow whenever weather permits. It is held by some that the roots are a normal wintering place of the lice and it is entirely possible that while a part may spend the winter this way others may hibernate on other plants. So far as I am informed no eggs of this species have yet been found. That they occur, however, on some unknown plant we can hardly doubt.

REMEDIES FOR PLANT LICE.

As we have already indicated, plant lice receive their nourishment by extracting the juices of the plant through a beak the setae of which are inserted into and among the plant cells. They do not eat the surface parts as do caterpillars, beetles etc. hence

any amount of poison on the surface of the leaf does not affect them. Their rostral setae pass through such a coating of poison and extract the unpoisoned sap beneath. Contact insecticides, as their name implies, kill by coming in contact with the body. It follows, then, that in order to be effective a spray with a contact insecticide must be brought in actual contact with all of the insects to be killed. It does not harm a plant louse to walk over or feed upon a leaf that has previously been sprayed with a kerosene emulsion, whale-oil soap or other contact insecticides. When it is a habit of a species to feed on the under side of the leaves, it is necessary to direct the spray against the under side. When they feed on both surfaces, it is necessary to touch both surfaces with the spray. By studying the catalogues of the various makers of spraying apparatus, which can be obtained on application, one can find apparatus suited for under spraying and can select pumps best suited to his needs. It is to be regretted that more pumps and complete outfits are not owned by property holders in Montana. We are fast coming to the time when every fruit grower and owner of any considerable estate will find it an absolute necessity to be thoroughly equipped with a spraying outfit. Such outfits can be obtained through local hardware dealers.

We may consider remedies for plant lice under two headings, (1) those applicable to root forms and (2) those applicable to aerial forms.

Having become aware that the roots of an apple or other tree are affected with plant lice it is necessary to bring a substance in contact with their bodies if we will destroy them. Hot water is, perhaps, all things considered, the remedy of most general application, and while simple and inexpensive, when properly used, is thoroughly effective. Water nearly up to boiling point may be applied about the base of young trees without danger of injury to them. It is usually advisable to first remove the surface soil in order to facilitate reaching them with the hot water. Woolly aphids may penetrate at least a foot into the earth.

Finely ground tobacco leaves or tobacco stems may be used for the same purpose. While this substance may be used with impunity about the roots of plants, it affords a preventative as well as a remedy. This tobacco dust is sometimes strown in the furrow in which nursery stock is to be planted.

Bi-sulphide of carbon is sometimes used as a remedy, but its use unless in the hands of an experienced person is dangerous to the trees, for when brought in contact with the roots in any considerable quantity it kills them. By a careful person it may be applied in three or four holes around the roots of a tree, not closer than about one and a half or two feet to the crown. One or two tablespoonfuls of the liquid should be poured into each hole. The vapor of this liquid penetrates the earth and kills as many of the lice as it reaches.

This vapor is highly inflammable and care should be taken in using it not to bring a lighted match or cigar or flame of any kind within reach of the gas. The substance can be obtained in quantity at about 10 cents a pound.

Plants known to be infested with root lice should not be accepted as nursery stock or, at least, should be thoroughly treated by dipping them into water of sufficiently high temperature to kill the lice.

Among the contact insecticides may be mentioned kerosene emulsion, and whale-oil soap solution, which, all things considered, are the most useful. It is sometimes more convenient to use the soap solution made with ordinary soaps. Formulae for the preparation of these washes are to be found in Bulletin 51 of this Station which may be obtained by writing to the Director. This bulletin also discusses methods of fumigation with the poisonous hydrocyanic acid gas and its application in the treatment of apple aphids.

It is very often the case that only here and there a limb is affected with an aphid and it is often possible to go through an orchard or garden and dip the affected parts of trees in a pail or pan of kerosene emulsion. This method is much more simple than spraying.

HORTICULTURAL DEPARTMENT.

R. W. FISHER, Assistant Horticulturist.

The past year has seen wonderful advances along horticultural lines throughout the state, and emphasizes the need of further equipment and facilities in this department for carrying on experimental and research work.

Fruit growing, especially apple production and the small fruits, is considered among the most profitable crops that are grown on the farm, and where vegetable gardening has been given thorough and business-like attention, it also has proved very remunerative.

There is yet much to be done in originating and testing new varieties both of fruits and vegetables. A winter apple, superior to anything we now have, would be a boon to the Montana orchardist, and the determination and selection of the best adapted vegetables will be of great benefit to both the market gardeners and to those who grow vegetables for their own use.

Work has begun along these lines, and some facts have been determined in regard to the varieties of fruits likely to do best and the kinds of vegetables best adapted to our conditions. Considerable work has also been done with ornamental trees and shrubs, but the work has not extended over a period long enough to warrant publication, other than is to be found in other reports from this department.

WEATHER CONDITIONS.

In making a report upon the growth and production of horticultural crops, it seems advisable to give a summary of the weather conditions during the growing season. This will form a basis for comparison with other parts of the state not similarly situated with reference to climatic conditions.

The last frost experienced this season was during the night of May 24, when the thermometer registered 30 degrees F., or 2 degrees below freezing. On May 18 we had 11 degrees of frost, which was the lowest temperature for the month.

As there were no vegetable seeds yet planted, and the trees and shrubs not yet in bloom, the frost did scarcely any damage. A few tender leaves were injured some, but did not affect the subsequent growth to any extent. Although we did not have a frost as late as usual in this locality, yet the germinating and growing season was from a week to ten days later than in former years. This no doubt was due to the average cold weather of the spring months.

The first fall frost occurred on September 11, when it was 32 degrees F., or freezing. This was accompanied with a fall of snow, which lay on the ground for several days. On the 12th the thermometer registered 30 degrees F., and on the 13th 27 degrees, being the lowest for the month. This frost did considerable damage to tender vegetables, green fruit, and many trees and shrubs. Beans, corn, cucumbers, tomatoes, squash, etc., were totally destroyed, in cases where they were not ripe.

The plum crop was materially damaged. The fruit was just beginning to ripen when the frost occurred, and it spoiled almost the entire yield of the cultivated plums. The wild plums suffered but little. The apples were not affected to any appreciable extent. The terminal shoots and buds on small fruits, as raspberries, blackberries, and dewberries, were damaged and many leaves blighted. The leaves and terminal shoots on many trees and shrubs were also frosted, and no doubt affected the normal ripening process considerably. Those hurt the most are:

Russian mulberry.
 Western catalpa.
 Silver maple.
 American elm (young trees).
 Box elder.
 Poplars.
 Sugar maples (slightly)
 Black walnut. "
 Scotch labernum "
 Purple lilac "

With the exception of the poplar, the above-named trees and shrubs were small, having been set out in June of this year.

The following chart gives the temperature and rainfall from May 1st through September:

1903	Aver. day temp.	Aver. night temp.	Mean	Highest	Lowest	Rainfall
May	59	34	47	83	20	2.04 inches
June	73	48	61	84	39	2.49 "
July	74	47	60	87	34	2.77 "
August	78	49	64	91	40	.50 "
September	65	38	51	82	27	1.11 "

Altitude about 4,874 feet above sea.
 110 days between frosts.

COMPARATIVE YIELD OF APPLES.

During the past two years a record has been kept of the yield of fruit from each tree in the orchard, and the results are summarized in the following table.

The test has not been in operation long enough to thoroughly determine the yield of the different varieties, but from a test of two years it will give some hint as to the comparative production of the different varieties. All trees in the orchard received the same treatment, and most of the bearing trees are of the same age, the oldest trees being eight years in the orchard.

Variety	No. of trees bearing	Yield in pounds, 1902	Yield in pounds, 1903	Total	Av. per tree for 2 years	Remarks
Anisette	3	36.5	27.5	64	21 1/3	Similar to Duchess
Charlottenthaler.....	5	2	81	83	16 3/5	" Yel. Trans.
Duchess	4	83	121	204	51	Early fall
Gideon.....	3	18	131	149	49 2/3	Early winter
Gipsy Girl.....	1	2	7	9	9	Early to late fall
Gano	3	1 1/2	15	15.5	5 2/3	Winter
Hibernal.....	3	4	206	210	52.5	Early to late winter
Longfield.....	2	82	59	141	70 1/2	" winter
12 M.....	3	3	108	111	37	" "
Okabena	4	179	59	238	59 1/2	Late fall to early winter
Orel	1	4 1/2	17 1/2	22	22	" " " " "
Persian	1	4	17	21	21	" " " " "
Royal Table.....	3	225	90	92	31	Early winter
Am. Golden Russett	2	55	80	135	67.5	Late fall to early winter
Thompson's No. 10....	1	2	99	101	101	Early to late winter
Tetofsky.....	1	13	14	27	27	Summer to early fall
Veronesch	3	2	98.5	100.5	50	Fall
Wealthy	4	48	228	276	69	Late fall to winter
Yel. Transparent.....	2	60 1/2	183	243.5	121.7	Summer to early fall
CRABS—						
Bailey's Crimson.....	1	85	28	113	113	Fall
Florence.....	1	10	20	30	30	"
Greenwood.....	3	271	20	291	93	"
Hyslop.....	2	207	15	222	111	"
Martha	1	4	4.5	8.5	8.5	"
Orange	2	156.2	199.5	359	178	"
Pride of Minneapolis..	1	11	43	54	54	"
Transcendent	5	661	299	960	192	"
Whitney No. 20.....	4	56	86	142	35 1/2	"

DISTANCE APART TO PLANT TREES.

The trees in the Station orchard were set 17 1/2 feet apart either way, and after eight years' growth we find that many of them are entirely too close together.

With such vigorous and spreading varieties as Hibernal, Longfield, Wealthy, and crabs, it is almost impossible to cultivate between them with two horses without rubbing and barking the limbs, and there is no doubt but that their full development cannot be gained when the limbs are intertwining:

The old advanced theory that trees planted close together would protect each other has been given up, and in cases where trees need protection, paper or some other substance is wrapped around the stem. Low heading and good pruning can be made to afford all the necessary protection from the sun after the trees have attained bearing age.

From my observations throughout the state, and experience gained from the growth of trees at the Station, I would recommend that standard apple trees be not planted closer than 20 feet apart, and with natural spreading varieties greater distance is necessary.

Plums and cherries may be planted somewhat closer, but it is best always to give plenty of room for future development.

GARDEN NOTES.

Variety tests of common garden vegetables were carried on this year, the purpose being to select the varieties best adapted to our conditions and the cultural methods that will give the greatest satisfaction.

About 40 varieties of beans, 12 of tomatoes, 20 of cabbage, 2 of cauliflower, 1 of broccoli, 9 of corn, 10 of onions, 6 of cucumbers, 3 of beets, 2 of squash, 1 of muskmelon, 1 of watermelon, 3 of lettuce, 3 of radish, and 5 of celery were included in this year's test of vegetables.

BEANS.

In our tests of varieties of beans, we have not yet found a variety of Lima bean that will mature. The following table gives the comparative yield per acre of the different varieties of string, or bush beans, and the date at which they were ready for use, as string or snap beans. All varieties were planted June 2d, 1903, and harvested from September 23d to October 15th.

	Variety	1st snap	Wt. in lbs. per acre	Color of seeds
1	White seeded Wax	Aug. 10	6238	White
2	Long Yellow Six Weeks	" 7	5162	Yellow
3	Improved Black Wax	" 10	2796	Black
4	Dwarf Horticultural	" 10	2817	Cream, spotted
5	Henderson's Cream Valentine	" 10	2183	Cream
6	Henderson's Bountiful	" 7	2726	Yellow
7	White Marrow	" 7	2372	White
8	Golden Wax	" 7	1584	White and purple
9	Improved Golden Wax	" 7	3839	White, purple eye
10	Early Mohawk	" 7	1819	Purple and cream
11	Wardwell's Kidney Wax	" 7	2254	White, purple eye
12	Henderson's Earliest Red Valentine	" 10	1201	Red striped
13	Keeney's Rustless Golden Wax	" 10	1856	White, drab eye
14	Valentine Wax	" 10	1065	Red; spotted
15	Henderson's Black Valentine	" 10	550	Black
16	Early Warwick	" 7	878	Red; spotted
17	Extra Early Refugee	" 10	716	Blue; speckled
18	New Early Bush, Burpee's Brittle Wax	" 7	3071	White, black eye
19	Flageolet Wax	" 10	909	Red
20	Golden Eyed Wax	" 10	1817	White, golden eye
21	Large White Kidney	" 10	2280	White
22	Golden Champion Wax	" 18	not mature	—
23	Davis Wax	" 10	6066	White
24	Longfellow	" 10	2495	Drab; speckled
25	Everbearing, or Inexhaustible	" 15	946	Mixed colors
26	Jone's Stringless Wax	" 11	3355	White
27	Blue-podded Butter	" 18	not mature	—
28	New Pencil-pod Black Wax	" 11	1888	Black
29	Improved Rust-proof Golden Wax	" 10	1344	White, spotted
30	White Marrowfat Bush	" 12	4033	White
31	Currie's Rust-proof Golden Wax	" 15	2084	Dark purple
32	Crystal White Wax	" 18	not mature	—
33	Davis' Dwarf White Wax	" 12	" "	White
34	New Prolific German Wax	" 15	" "	Black
35	China Red Eye Bush	" 13	4667	White, red eye
36	Burpee's Perfection	" 12	2968	Black-brown
37	Round Yellow Six Weeks	" 7	1959	Yellow
38	Dwarf German Black Wax	" 10	3183	Black
39	New Giant Stringless Greenpod	" 12	4667	Light brown
40	Burpee's Stringless Greenpod	" 13	3721	Dark brown
41	Extra Early Red Valentine	" 7	3635	Red striped
42	The Goddard	" 15	not mature	—
43	Improved Bush Lima	" —	" "	—
44	Best of All Bush	" 15	2301	Cream and red

CABBAGE.

This year's test verifies the results obtained in previous years. The best early variety from a standpoint of productiveness was Succession. It also was one of the earliest varieties to mature.

The best late cabbages this year were Late Stonehead and Danish Round Head. The experience gained the past two seasons in growing late cabbage leads to the conclusion that plants should not be set out later than June 15. Unless we have exceptionally fine fall weather, many varieties do not mature when set out as late as July 1st.

Cabbage, set June 8, Harvested Sept. 7.

Variety	Ready for use	Average wt. per head	Yield in lbs. per acre
Succession	Aug. 1	5 lbs.	36,300
Early York	" 4	2.8 "	20,328
Charleston Wakefield	" 4	4.8 "	34,848
Early Spring	" 4	4.1 "	29,766
St. John's Day	" 1	4.9 "	35,574
Early Stonehead	" 10	4.2 "	30,429
Henderson's Summer	" 5	4.7 "	34,122
Ey. Jersey Wakefield	" 1	3.05 "	22,143
Early Base Ball	" 10	2.4 "	17,424
Danish Round Head .....	.....	1.8 "	13,068
Early Winningstadt	Aug. 10	1.7 "	12,342

Winter Cabbage, set out July 1, Harvested October 28.

Variety	Average Wt		
Late Stonehead	6.1 lbs.	44,286	Solid, very firm
Fottler's Improved Brunswick	3.5 "	25,410	Not all firm
Danish Round Head	4.9 "	35,574	Solid and firm
Late Flat Dutch	4.5 "	32,670	About 75 per cent very good
Red Dutch Pickling	2.5 "	18,150	Poor, not all mature
Mammoth Rock Red	1.9 "	13,794	" " " "
Danish Ball Head	2.5 "	18,150	" " " "
Autumn King	3.25 "	23,595	Not mature
Holland	2.2 "	15,975	Poor, not mature

CAULIFLOWER.

Two varieties of this vegetable were grown this year, Best Early and Dry Weather. The Best Early variety was ready for use about one week before Dry Weather, but does not form as large or firm a head.

SWEET CORN.

The following varieties of sweet corn were grown this year:

Burpee's Cosmopolitan, Country Gentleman, Crosby's Early, Early White Cob Cory, Burpee's Early Sheffield, The Henderson, Burpee's Dread Naught, White Evergreen, and Golden Bantam. Six of these varieties did not make "roasting ears." Burpee's Cosmopolitan matured about 30 per cent, Crosby's Early about 50 per cent, and Early White Cob Cory matured a full crop by September 10, after which date all were killed by frost.

On account of its earliness the Early White Cob Cory is by far the best variety tested. The ears are small, but of good quality, and the plants are dwarf, enabling them to be closely planted.

The corn was planted May 25, in rows 4 feet apart, and the hills 18 inches apart in the rows, with about five stalks to a hill, and irrigated up until August 15.

BEETS.

Improved Blood Turnip, Dark Stinson and Columbia were the only varieties of beets grown this year. Improved Blood Turnip reached merchantable size July 28, Dark Stinson and Columbia August 6. The Improved Blood Turnip also gave the largest yield per acre of the varieties tested.

CUCUMBERS.

Four varieties—Extra Early Green Prolific, Fordhook Famous, Extra Early White Spine, and Thorburn's New Everbearing—were planted June 3d. Thorburn's New Everbearing produced the first cucumbers of marketable size, and of the varieties tested this year was the best for pickling. Burpee's Fordhook Famous proved a very good cucumber for table purposes, although a little later and not so prolific as the Everbearing variety.

CELERY.

The results with this crop were about the same as in previous years, the White Plume and Self Blanching varieties being the best early, and are also much easier to bleach than the Giant Pascal, which has proved so far to be the best late or winter variety.

ONIONS.

Variety and cultural tests were made with onions. Seeds were planted in flats in the greenhouse on April 20th and transplanted into the open ground May 26th, at which date seeds of the same varieties were planted alongside of the transplanted onions, in order to give a comparison between the two methods in the growth and ripening of the bulbs.

May 26th was as early as seed could be planted out here this season, unless the ground had been prepared the previous fall. The transplanted onions were about two weeks earlier in maturing than the seedlings—in fact, some of the seedlings did not mature at all—and produced much larger and firmer bulbs and of a more uniform size.

On account of the small area planted to onions, we could not make an exact comparison between the amount of labor involved in the two methods, but I do not think it takes any more, if as much, labor to transplant the seedling from a flat or hotbed as it does to thin the plants in the field. Of course by transplanting we lose the bunch onions, that are sometimes quite an item to the market gardener, and often more than pay for the thinning. However, if one is growing onions for the mature bulbs, I firmly believe that the transplanting method has many advantages over seeding in the open ground, and will make onions a sure and paying crop in Montana.

The following table gives the varieties tested, the average weight of the seedling bulbs and the average weight of the transplanted onions, showing an average difference of over .2 of a pound in favor of the transplanted onions:

Variety	wt. of lings	wt. of tr'planted	
Adriatic Barletta.			White, flat, no neck, does not keep long
Australian Brown . . . . .	.16	.34	Thin neck, very firm and keeps well
Southport Large Yellow Globe. . . . .	.20	.47	Thin neck; very good
Ex. Early Australian Yellow Globe . . . . .	.17	.34	Thick neck; keeps well
Flat Red . . . . .		.44	Good; keeps well
Prizetaker. . . . .	.16	.39	Good; keeps well
Large Red Globe . . . . .	.13	.28	Fair
New Mammoth Silver King. . . . .	.15	.41	Good; firm, good keeper
New Giant Gibraltar . . . . .	.13	.36	Did not keep long
Burpee's Nameless.	—	.30	Good keeper
Average . . . . .	.16	.37	

With rows 18 inches apart and the onion bulbs 4 inches apart in the row, we have about 87,120 onions per acre. The average weight of the seedlings in this year's test, all varieties, was .16 pounds, or at the rate of 13,939 pounds per acre, while the transplanted onions yielded, figuring on the same basis, at the rate of 32,334 pounds per acre, a gain over the seedling of 18,395 pounds to the acre.

SQUASH, ETC.

Seeds of Warted Hubbard, Fordhook and Golden Hubbard were planted on June 3d. The Warted and Golden Hubbard matured a few squash, although the vines were killed early in September.

Watermelons and muskmelons did not mature any fruits.

TOMATOES.

Tomato seeds of 12 varieties were planted in the greenhouse in April and transplanted into the open June 3d. In order to get ripened fruits it is necessary to start the plants early and get them into the open ground as early as danger of frosts is past. They will mature crops better when planted in a soil that does not induce too strong plant growth. From experiments at the Station it has been determined that a moderately heavy clay soil will produce the most ripe fruits. By giving plenty of water and good

cultivation early in the season the plants will make their growth, and later, by withholding the water and ceasing cultivation, it will induce the tomatoes to ripen earlier than they otherwise would.

Variety	First ripe	No. lbs. ripe fruit	No lbs. green fruit	Total per cent ripe	Lbs. ripe to an acre	
Mikado.....	Aug. 13	16.75	40	29.5	3040	50 per cent rough
Quarter Century	Jul. 28	13.5	26	34.1	2470	Smooth
Chalk's Early Jewel	Aug. 5	25	35	41.6	4537	Some rough
Dwarf Champion.....	Jul. 28	19.125	27	41.4	3470	Smooth
Ponderoso	Aug. 5	18.62	61	23.3	3379	Rough
Early Ruby.....	" 5	27	67	28.7	4900	Mostly smooth
Livingston's Stone	" 13	13.51	30	31	2450	Smooth
Burpee's Noble.	" 26	1.43	28	4.9	259	Smooth
Perfection	" 15	3.5	47	6.9	635	Smooth
Matchless	" 23	2.68	—	—	486	Smooth
Stone	" 23	.75	—	—	136	Smooth
Giant Tree	Sept. 1	.187	—	—	33	Smooth



BOTANICAL DEPARTMENT.

J. W. BLANKINSHIP, Botanist.

The work of the Botanist for the present year has been largely a continuation of lines previously begun. The results of the study of the principal plants poisonous to stock in this state have been embodied in Bulletin No. 45 (June, 1903) of the station. "The Loco and Some Other Poisonous Plants in Montana," in which special investigation was made of the loco trouble in the central part of the state and methods devised for its avoidance during the periods of danger.

ECONOMIC PLANTS OF THE INDIANS.

A large amount of data relating to the economic plants of the Indians and early settlers has been collected and will be ready for issue in a provisional bulletin at an early date. It is the more important that this information concerning the useful properties of our native plants be now secured, as the people who were driven by stress to seek out and utilize these properties are rapidly passing from the stage of human activity, and with them will perish all this valuable information, learned with such difficulty, and because, with the increasing complexity of civilized life, continual demands will be made upon every department of Nature to supply certain wants not previously provided for. A good instance of this is the actual discovery of the peculiar adaptability of the native "blue-joint" grass to growth and cultivation for economic purposes, as mentioned hereafter.

FORESTRY.

Considerable attention has been given to the forest conditions of the state, the various species of trees and shrubs here native have been identified, and their distribution largely ascertained, as well as the uses to which they are severally adapted, with a view to the prevention of the present wasteful methods of lumbering and to restricting the range of the many forest fires which ravage our mountains every summer and leave in their wake the bleaching skeletons of the growth of many years, which else might go to build and warm and fence many thousands of homes which improved methods of irrigation may render possible. It is only a question of time until the state must undertake more careful supervision of these natural resources and attempt systematic reforestation to supply an increasing demand for these products now so lavishly wasted.

ALKALI PLANTS.

The alkali plants of the state are being brought together and studied, with a view to the rough determination of the relative amount of alkali in the soil by the plants it produces, and that experiments may be attempted in growing forage plants adapted to such conditions.

BIOLOGICAL SURVEY.

In connection with the other work of the Botanist, a systematic attempt is being made to study the distribution of the native plants of the state in the relation to soil, climate and altitude, on the theory that like conditions of climate and soil will support a similar native vegetation, and that through this flora the agricultural and horticultural possibilities of any given sec-

tion may be predicted by the crops and fruits found adapted to another section with a similar flora. This biological survey has now been continued in connection with the other work of the Station for some six years, and an herbarium of some 20,000 specimens has been prepared as the basis for determining these species and their distribution, as well as for other scientific work in pure and applied botany. The unidentified collections have now been taken to the Gray Herbarium at Harvard University for determination. It is hoped, from the material now on hand and from the field work of the ensuing season, it may be possible to map out and characterize most of these different biological zones of the state and to indicate in general their economic possibilities. In connection with this work of the survey, a set of plants representative of the flora of the state is being prepared for exhibition at the World's Fair in St. Louis.

FORAGE PLANTS.

An effort has been made to cultivate at the Station certain forage grasses deemed suitable for growth on the semi-arid ranges of the state, to replace the native forage plants exterminated by close grazing. Several species of "blue-joint" (*Agropyron*) have been grown for several years, and appear to thrive under natural conditions, but for some reason the attempt to secure a stand of the "buffalo-grass" (*Bouteloua oligostachya*, Torr) was unsuccessful, though it has been found to yield readily to cultivation in some other states. A large supply of the seed was secured during the summer, and further attempts will be made, as this is the most promising species for the upland ranges, where it is already well established in many parts of the plains region eastward.

In regard to the "blue-joint" (*Agropyron occidentale*, Scribn) it may not be generally known that this species of native grass is already cultivated extensively over much of the irrigated section of the Milk River valley about Harlem, Chinook, and on the Big Sandy south of Havre, and that many thousand tons of this "blue-joint" hay are put up each season in these sections for the

use of the local stockmen, and even placed upon the market in considerable quantity, commanding a higher price than the best timothy or alfalfa for fattening and finishing stock for the market. So that the experimental stage, at least, of this new forage grass may be said to have been passed.

In the low valley lands this species will yield without irrigation about one ton per acre, and is indeed the chief constituent of most of the "wild hay" cut in the state outside of the mountain sections. Under irrigation it is said to yield from two to six tons per acre, averaging about three around Harlem, in the Milk River valley.

The method of growth around Harlem, where its culture has been most highly developed, is to irrigate the meadows thoroughly once between March and June—the earlier the better—and to cut about the middle of August; but the grass stays green all summer long, and may be cut at any time most convenient, though the ripening of the fruit in August would seem to render later cutting of less value. Considerable growth is made after the August cutting, and this is used for winter pasturage, frost in no wise injuring its value as a forage.

In the Milk River valley about Harlem there is little slope to the valley lands, so that the flood method of irrigation is employed—the only locality in the state, I believe, where this is undertaken on an extensive scale. Squares of from 10 to 40 acres are enclosed by low dykes and the water is allowed to flow over these squares till the ground is covered several inches deep and the soil becomes thoroughly saturated. The dyke is then opened at the lowest point and the water drained off into another similar area. This method of irrigation saves much work, and has the added advantage of tending to leech out from the soil the alkali, always excessive in this valley under other methods of irrigation.

In the matter of economy of production this grass compares favorably with timothy and alfalfa. No plowing or sowing is necessary at any time, as the grass appears to spring up spontaneously from underground rootstocks present in nearly all the lowlands of the state; and it is stated that it is often difficult to eradicate the grass, even when such meadows are plowed up and

planted in grain for as many as six successive years. When such lands are left fallow and irrigated they shortly produce as good hay as ever.

The blue-joint will stand quite as much alkali in the soil as alfalfa, while too much irrigation, extreme cold, or excessive drought have little permanent effect upon its growth. The soil of this blue-joint region is a sandy loam, with some clay, called "gumbo," but the blue-joint seems to grow equally well on both.

Stockmen everywhere claim superiority for this blue-joint hay in finishing stock for the market, and some claim that a ton of blue-joint equals in value about one and one-sixth tons of timothy, or one and three-fourths of alfalfa. This yet awaits experimental proof, however. Blue-joint hay is easy to handle, and is said to excel in keeping quality.

This hay has been grown about Harlem for forage purposes some 17 years, and has been found more profitable and to need less care than any other crop. The species thus grown is almost pure *Agropyron occidentale* Scribn, other grasses with it being regarded in the nature of weeds.

Though it has not been found necessary to sow the seeds here to secure a stand, experiments at this Station show the grass is grown readily from ordinary planting, and seed could easily be obtained by thrashing, as the spikes break up readily when dry, and many bushels of the seed are left as waste at each baling place. A quantity of the seed has now been secured by this Station, and its agricultural value will be tested under more accurate conditions.

IRRIGATION DEPARTMENT.

S. FORTIER, Irrigation Engineer.

By J. S. BAKER, Agent.

THE RELATION OF SOIL MOISTURE TO CROP YIELD.

In the determination of the relation of the amount of water to the crop produced, six of the twelve tanks described in the Ninth Annual Report were used. The other six were left fallow for the determination of the evaporation from bare soils.

The tanks were carefully weighed on May 21 and on May 25, 65 kernels of wheat were planted. After germination the number of sprouts was reduced to 34 in order to have a uniform stand on all the tanks.

The tanks were kept at the normal temperature of the field soil, by applying water to the outside through a metal pipe, thus reducing the excessive temperature induced by the transmission of heat by the metal of the tanks.

The following figure No. 1 shows clearly the relation of water to crop. The total water received is the sum of the irrigation water and the rainfall. The legend at the bottom of the figure explains the meaning of the same. By a study of tables Nos. 1 and 2, the same relation may be found. In the third column of

table No. 1 is given the depth of the water received and in the eighth column of table No. 2 the yields of the tanks in bushels per acre. The same relation is also brought out in the last column of table No. 1 in which is given the number of pounds of water required to produce one pound of wheat.

Table No. I—Table showing the depth of water received by each tank and the relation of the quantity of water to the crop produced.

No. of Tank	Depth of Irrigation in Feet	Depth of Rainfall in Feet	Total Depth of Water Received	Pounds of Water to Produce One Pound	
				Of Dry Matter	Of Wheat
1 .....	.....	.558	.558	141	758
2 .....	.505	.561	1.066	171	1076
3	1.010	.561	1.571	214	793
4	1.514	.558	2.072	244	915
5	2.018	.558	2.576	268	1012
6	2.521	.558	3.079	300	1015

Table No. II—Table showing yields of tanks and increase of crop from seed.

No. of Tank	Weights of Crop			No. of Kern-els	*Rate of In-crease Seed to Crop	Yield Per Acre		Remarks †
	Straw	Wheat	Total			Cwt.	Bus.	
	Ozs.	Ozs.	Ozs.					
1..	5.70	1.30	7.00	350	1 to 10	20.03	33.8	Wheat badly shrunken, uniform sized kernels.
2..	9.25	1.75	11.00	745	1 to 22	26.96	44.9	Shrunken, uniform size.
3..	9.50	3.50	13.00	1200	1 to 35	53.93	89.9	About one-third kernels small.
4..	11.00	4.00	15.00	1750	1 to 51	61.63	102.7	About one-fourth kernels small.
5..	12.50	4.50	17.00	2900	1 to 85	69.34	115.5	About one-eighth kernels small.
6..	12.80	5.36	18.16	3090	1 to 91	82.58	137.6	Kernels uniform in size.

*Increase is based upon the number of kernels in crop and the number of sprouts in each tank.
†All kernels were small.

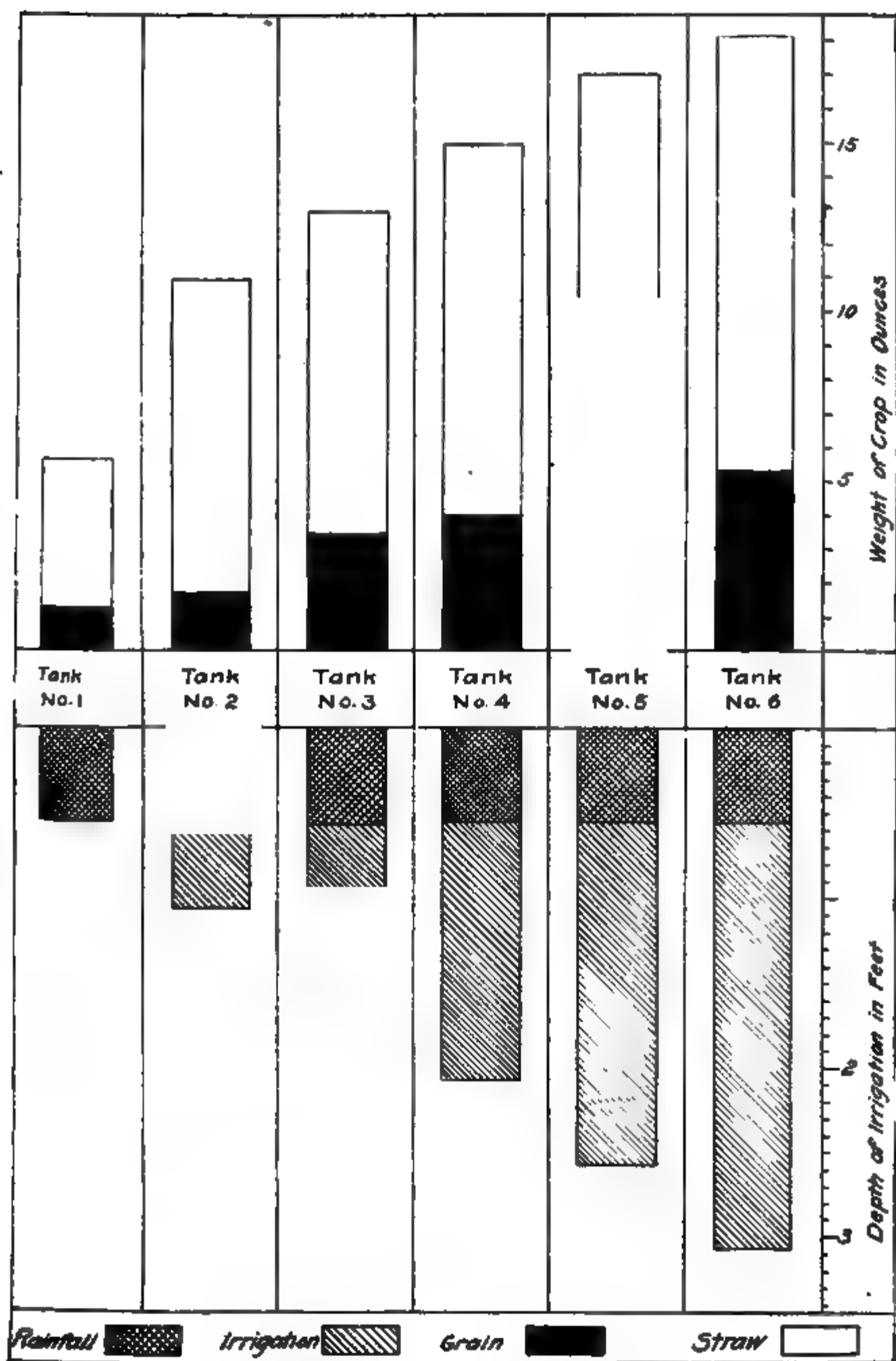


FIG. 1.

EVAPORATION FROM SOILS.

On May 21 all the tanks were weighed and again on July 11. Nos. 1 to 6 were seeded and Nos. 7 to 12 were left fallow. Approximately the same quantities of water were added to Nos. 1 and 7, 2 and 8, 3 and 9, 4 and 10, 5 and 11, 6 and 12, and they are arranged thus in pairs in the following tables Nos. 3, 4 and 5. Table No. 3 gives the results of the experiment from May 21 to July 11, and table No. 4 gives the results from July 11 to August 8 when the tanks were last weighed. Table No. 5 shows the results of the experiment for the entire season from May 21 to August 8. By consulting the last table we may see that with one exception—in the pair 3 and 9—that there is much more loss of moisture from the cropped soils. In this exceptional case there may have been some error in the weighing. The minus sign in the last column of tables Nos. 3, 4 and 5 indicates that there was more moisture drawn from the soil than was received during the experimental period, thus robbing the soil of moisture which it contained before seeding.

Table No. III—Table showing evaporation and transpiration from soil tanks from May 21 to July 11, 1903.

No of Tank	Weight of Tank May 21	Weight of Irrigation Water	Weight of Rain-fall	Total Amount of Water Received		Weight of Tank July 11	Evaporation and Transpiration		Difference Between Evaporation Plus Transpiration and Irrigation Plus Rainfall
	Lbs	Lbs.	Lbs.	Pounds	Depth in Feet	Pounds	Pounds	Depth in Feet	Feet
1	462	.....	37.18	37.18	.337	424	75.18	.681	- 0.344
7	483	.....	37.18	37.18	.337	474	46.18	.418	- 0.081
2	473	.....	37.18	37.18	.337	442	68.18	.617	- 0.280
8	488	.....	37.18	37.18	.337	478	47.18	.427	- 0.090
3	467	.....	37.18	37.18	.337	433	71.18	.645	- 0.313
9	481	.....	37.18	37.18	.337	489	29.18	.264	- 0.073
4	466	27.77	37.18	64.95	.588	462	68.95	.624	- 0.036
10	440	.....	37.18	37.18	.337	445	32.18	.291	- 0.046
5	477	55.55	37.18	92.73	.839	483	86.73	.785	- 0.054
11	490	.....	37.18	37.18	.337	490	37.18	.337	0.000
6	488	75.06	37.18	112.24	1.016	492	108.24	.980	- 0.036
12	475	.....	37.18	37.18	.337	472	40.18	.364	- 0.027

Table No. IV—Evaporation and transpiration from soil tanks. From July 11 to August 8, 1903.

No. of Tank	Weight of Tank July 11	Weight of Irrigation Water	Weight of Rain-fall	Total Amount of Water Received		Weight of Tank August 8	Evaporation and Transpiration		Difference Between Evaporation Plus Transpiration and Irrigation Plus Rainfall
	Lbs.	Lbs.	Lbs.	Pounds	Depth in Feet	Pounds	Pounds	Depth in Feet	Feet
1	424	.....	21.00	21.00	.190	400	45.00	.407	- 0.217
7	474	.....	21.00	21.00	.190	463	32.00	.290	- 0.100
2	442	27.77	21.00	48.77	.442	478	12.77	.116	-- 0.326
8	478	27.77	21.00	48.77	.442	494	32.77	.297	- 0.145
3	433	55.55	21.00	76.55	.693	463	36.55	.331	-- 0.362
9	489	55.55	21.00	76.55	.693	483	82.55	.747	- 0.055
4	462	58.38	21.00	79.38	.719	434	107.38	.972	- 0.153
10	445	86.15	21.00	107.15	.719	463	89.15	.807	- 0.088
5	483	66.72	21.00	87.72	.794	452	118.72	1.075	- 0.281
11	490	122.35	21.00	143.35	1.218	490	143.35	1.298	0.000
6	492	66.72	21.00	87.72	.794	460	119.72	1.084	- 0.290
12	472	133.44	21.00	154.44	1.398	477	149.44	1.353	- 0.045

Table No. V—Table showing evaporation and transpiration from soil tanks. For the season, May 21 to August 8, 1903.

No. of Tank	Weight of Irrigation Water	Weight of Rain-fall	Total Amount of Water Received		Evaporation and Transpiration		Difference Between Evaporation Plus Transpiration and Irrigation Plus Rainfall
	Lbs.	Lbs.	Pounds	Depth in Feet	Pounds	Depth in Feet	Feet
1.....	.....	58.18	58.18	.527	120.18	1.088	- 0.561
7.....	.....	58.18	58.18	.527	78.18	.708	- 0.181
2.....	27.77	58.18	85.95	.779	80.95	.733	-- 0.046
8.....	27.77	58.18	85.95	.779	79.95	.724	-- 0.055
3.....	55.55	58.18	113.73	1.030	107.73	.976	-- 0.049
9.....	55.55	58.18	113.73	1.030	111.73	1.011	-- 0.018
4.....	86.15	58.18	144.33	1.307	176.33	1.596	- 0.189
10.....	86.15	58.18	144.33	1.307	121.33	1.098	- 0.042
5.....	122.27	58.18	180.45	1.633	205.45	1.860	- 0.227
11.....	122.35	58.18	180.53	1.635	180.53	1.635	0.000
6.....	141.78	58.18	199.96	1.810	227.96	2.064	- 0.254
12.....	133.44	58.18	191.62	1.735	189.62	1.717	-- 0.018

EVAPORATION FROM A WATER SURFACE.

A tank set by Prof. Fortier in June, 1899, near the Station office building, and described in the Ninth Annual Report, was used in determining the evaporation from the water surface. It is aimed to have the conditions as nearly as may be representative of the conditions existing in irrigation reservoirs, and it is for comparison with such reservoirs that these results are chiefly useful.

The evaporation from water surfaces varies considerably in different parts of the state, and for this reason a number of tanks will be placed in different sections, so that results may be obtained for each particular locality. One has already been located on the Cascade Sub-Station, on the plateau 15 miles south-east from Great Falls, and another on the Yellowstone Sub-Station, 1½ miles south-west of Billings. The results of the evaporation will be published in the next annual report.

The following table shows the depth of evaporation from a water surface at the Experiment Station at Bozeman, which is at an elevation of 4,865 feet above sea level, for the seasons of 1900, 1901, 1902 and 1903. The temperature given in the tables is that of the water in the tank.

EVAPORATION FROM WATER SURFACE AT BOZEMAN, MONTANA.

1900.

	April	May	June	July	August	Sept.	October
Mean temperature....	73° F.	.....	.....	55° F.	46° F.
Monthly evaporation..	5.52 in.	5.99 in.	3.59 in.	3.88 in.	2.74 in.	0.98 in.
Ave. weekly evaporation	1.24 in.	1.39 in.	0.80 in.	0.88 in.	0.63 in.	0.22 in.

Mean temperature 58°; total evaporation 22.70 ins.; average weekly evaporation 0.86 ins.

1901.

Mean temperature....	53° F.	59° F.	60° F.	68° F.	69° F.	56° F.	51° F.
Monthly evaporation*	0.89 in.	5.27 in.	4.20 in.	4.34 in.	5.27 in.	3.43 in.	2.79 in.
Ave. weekly evaporation.....	0.41 in.	1.19 in.	0.98 in.	0.98 in.	1.19 in.	0.80 in.	0.63 in.

Mean temperature 59.4°; total evaporation 26.17 ins; average weekly evaporation 0.92 ins.

*From April 15 to 30.

1902.

Mean temperature....	49° F.	54° F.	67° F.	65° F.	65° F.	54° F.	50° F.
Monthly evaporation..	2.11 in.	3.40 in.	3.30 in.	4.07 in.	3.60 in.	3.01 in.	1.55 in.
Ave. weekly evaporation.....	0.49 in.	0.77 in.	0.77 in.	0.92 in.	0.81 in.	0.70 in.	0.36 in.

Mean temperature 57.7°; total evaporation 21.04 ins.; average weekly evaporation 0.69 ins.

1903.

Mean temperature....	.....	61° F.	62° F.	64° F.	67.6° F.	68° F.	55° F.
Monthly evaporation..	.....	*1.12 in.	3.99 in.	3.90 in.	3.38 in.	3.36 in.	1.64 in.
Ave. weekly evaporation .....	.....	0.60 in.	0.93 in.	0.88 in.	0.76 in.	0.78 in.	0.37 in.

Mean temperature 62.9°; total evaporation 17.39 ins.; average weekly evaporation 0.73 ins.

*May 19 to 31.

DUTY OF WATER ON EXPERIMENTAL PLATS.

In the spring of 1903 Prof. S. Fortier selected a tract of land in the central portion of the Experiment Station Farm for the purpose of ascertaining with accuracy the duty of water on different crops.

Seven of these plats already had a stand of alfalfa and the spaces intervening were plowed and cultivated during the season. Six plats were seeded to wheat, six to potatoes and four were summer-fallowed.

Alfalfa plats Nos. 1 to 3, were 215 feet by 12 feet, containing 2,580 square feet or very close to one-seventeenth of an acre. All other plats were 12 feet by 242 feet, containing one-fifteenth of an acre. A space of six feet separated the plats from each other, which space was kept cultivated during the season.

The water was supplied through a small flume and measured by a weir. In order that no water should escape from the plats, an embankment was thrown up around each one and all the water held on until it had soaked into the soil.

ALFALFA PLATS.

The alfalfa was given its first irrigation on June 17 and 18, and the following depths were applied:

Plat Number	Depth of Irrigation in Feet	Height in feet of Alfalfa at time of Irrigation
1	0.500	1.58
2	0.000	1.46
3	0.667	1.46
4	0.667	1.33
5	0.833	1.58
6	0.833	1.75
7	0.833	1.83

The second irrigation was on July 21, at which time the following depths of water were applied:

Plat Number.	Depth of Irrigation in feet.	Height of Alfalfa in feet
1	0.00	2.67
2	0.00	2.17
3	0.00	2.50
4	0.00	2.67
5	0.250	2.83
6	0.250	2.83
7	0.417	3.00

The first crop was harvested on July 22, 23 and 24. The following are the yields of first cutting, in pounds, of dry hay:

Plat Number	Pounds	Plat Number	Pounds
1	360	5	500
2	155	6	610
3	290	7	665
4	270		

Third Irrigation July 27.

Plat Number	Depth of Irrigation in feet
3	0.167
4	0.250
5	0.250
6	0.333
7	0.333

Fourth Irrigation August 4.

Plat Number	Depth of Irrigation in feet
6	0.167
7	0.167

Fifth Irrigation August 10.

Plat Number	Depth of Irrigation in feet
3	0.167
4	0.333
5	0.333
6	0.333
7	0.333

Sixth Irrigation August 14.

Plat Number	Depth of Irrigation in feet
4	0.250
5	0.333
6	0.417
7	0.417

Seventh Irrigation August 20.

Plat Number	Depth of Irrigation in feet
6	0.167
7	0.333

Eighth Irrigation August 21.

Plat Number	Depth of Irrigation in feet
7	0.167

The **second** crop of alfalfa was harvested on September 13 with the **following** yields of dry hay :

Plat Number	Pounds of Hay
1	183
2	75
3	230
4	230
5	357
6	350
7	370

The **following** table shows the depths of irrigation water applied **during** the season, and the yields in pounds per acre :

Plat Number	Depth of Irrigation plus Rain-fall in feet	Yield in Pounds per acre
1	1.20	9,231
2	.70	3,910
3	1.70	8,840
4	2.20	7,500
5	2.70	12,705
6	3.20	14,400
7	3.70	15,375

WHEAT PLATS.

The wheat plats were seeded on May 20.

The following are the dates of irrigation with the depths of irrigation water received and the heights of the wheat:

First Irrigation June 19.

Plat Number	Depth of Irrigation in feet	Height of Grain at Time of Irrigation in feet
1	0.000	0.67
2	0.000	0.67
3	0.000	0.62
4	0.255	0.67
5	0.500	0.54
6	0.750	0.58

Second Irrigation August 3.

Plat Number	Depth of Irrigation in feet	Height of Grain in feet
1	0.000	1.84
2	0.333	2.00
3	0.333	2.00
4	0.333	2.00
5	0.500	2.17
6	0.500	2.33

Third Irrigation August 10.

Plat Number	Depth of Irrigation in feet.
1	0.000
2	0.167
3	0.333
4	0.333
5	0.333
6	0.333

Fourth Irrigation August 14.

Plat Number	Depth of Irrigation in feet
3	0.333
4	0.417
5	0.417
6	0.417

Fifth Irrigation August 20.

Plat Number	Depth of Irrigation in feet
4	0.167
5	0.250
6	0.333

Sixth Irrigation August 21.

Plat Number	Depth of Irrigation in feet
6	0.167

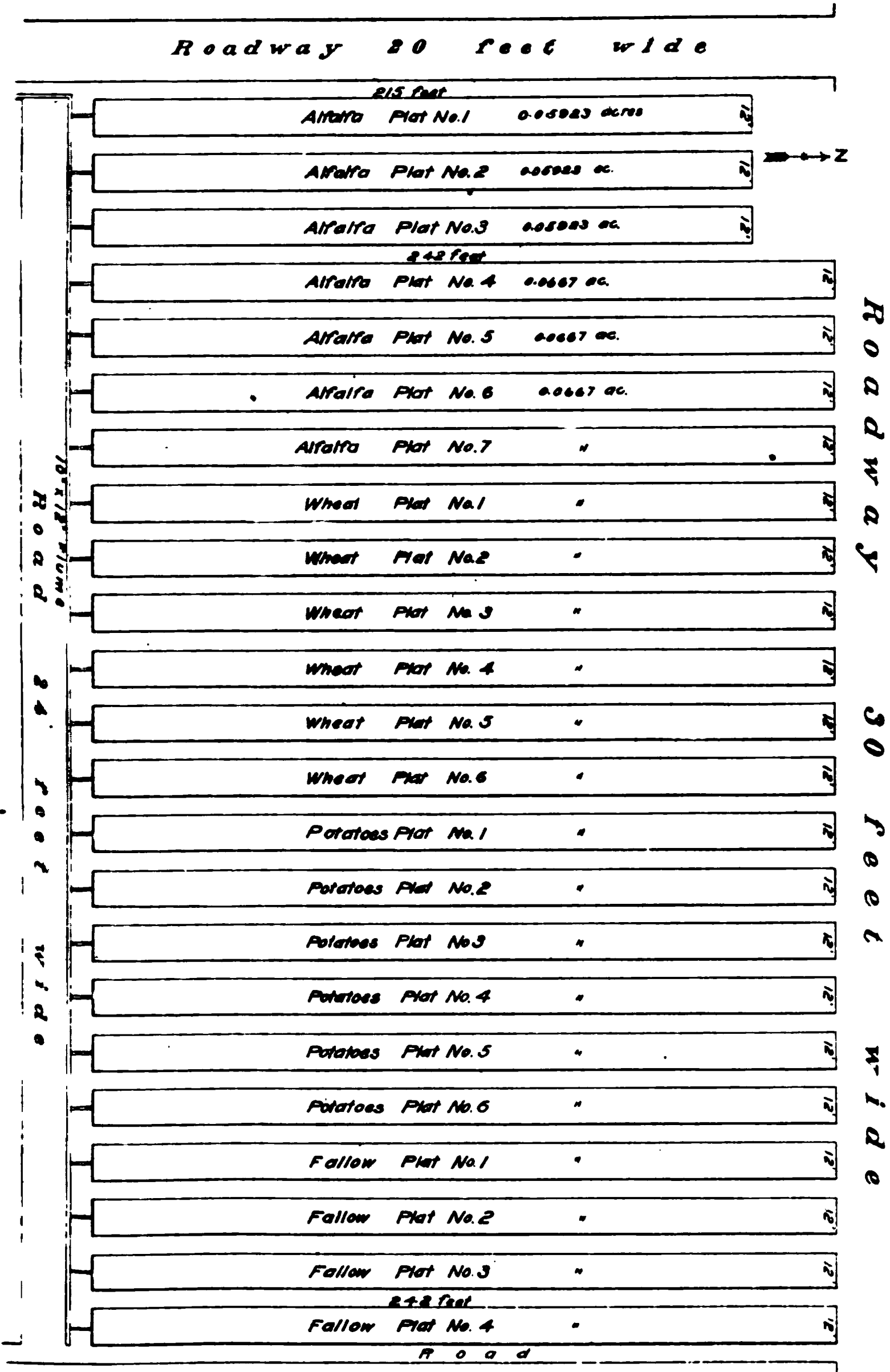


FIG. 2.

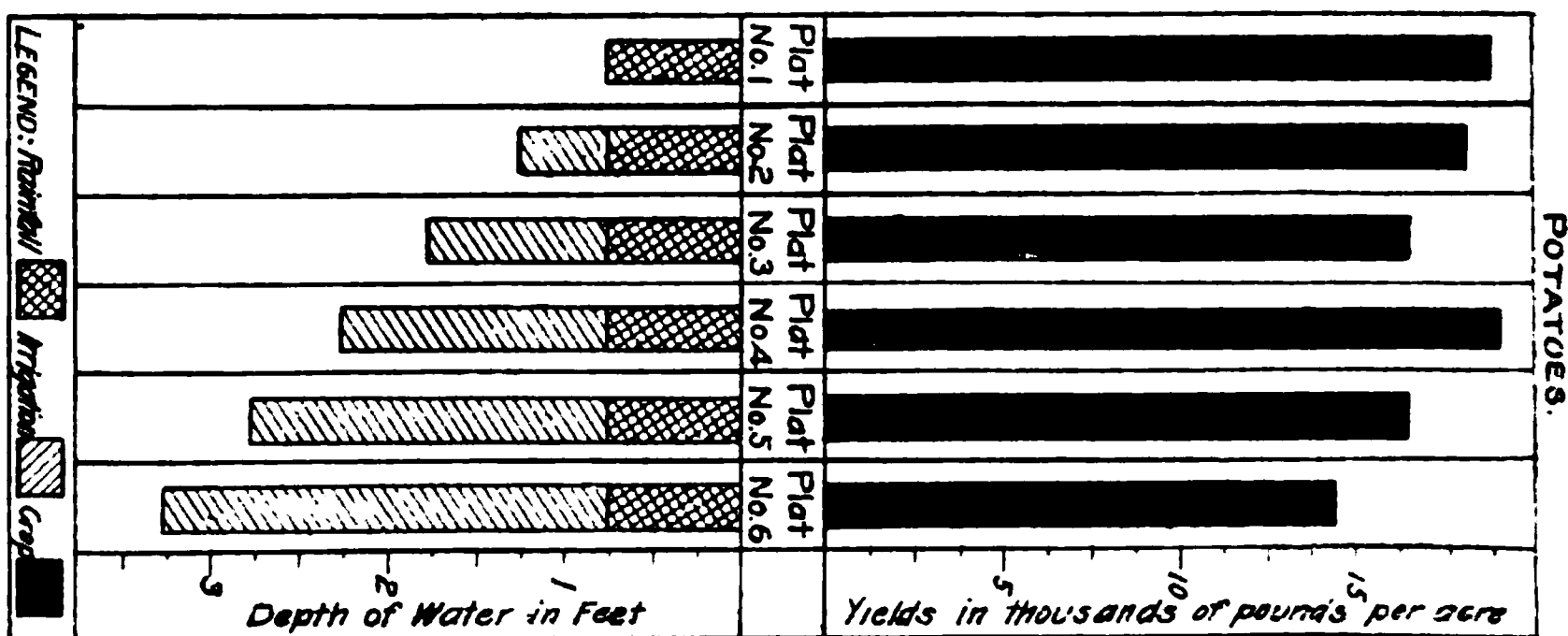
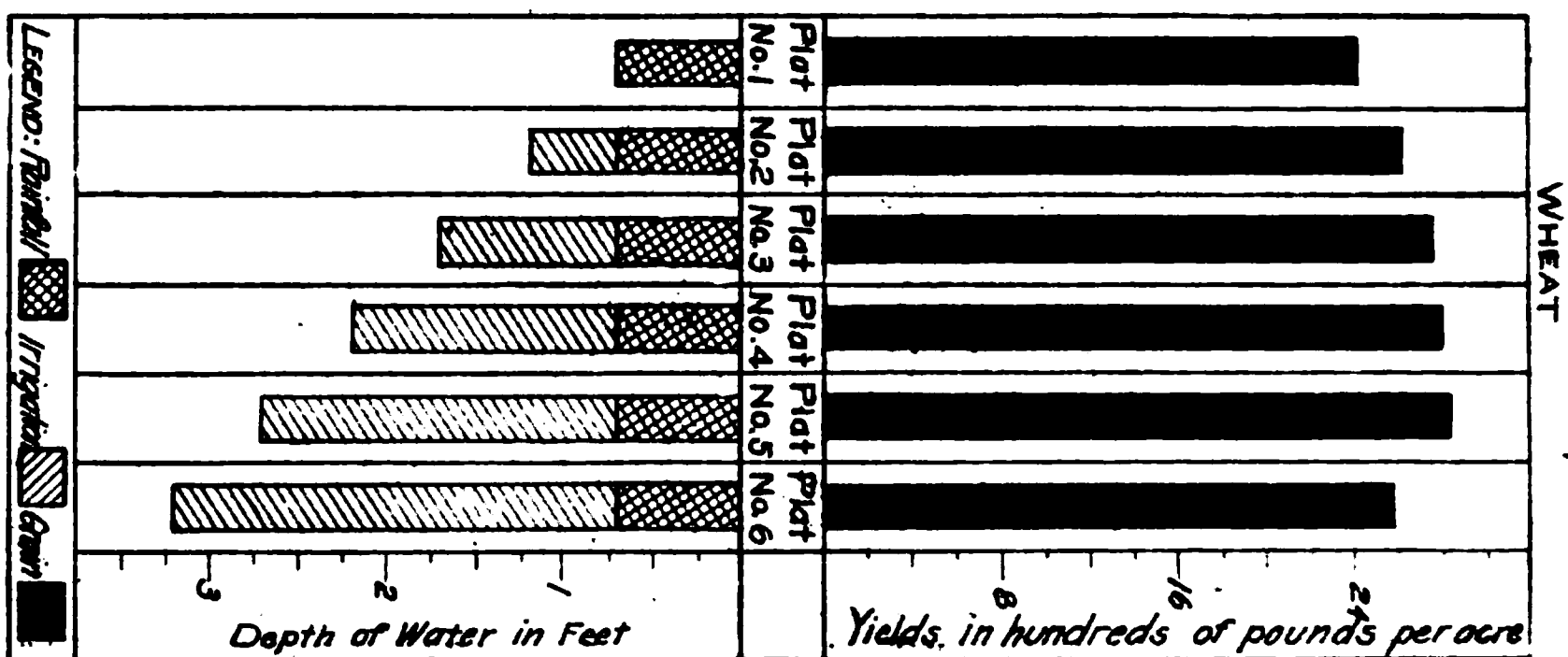
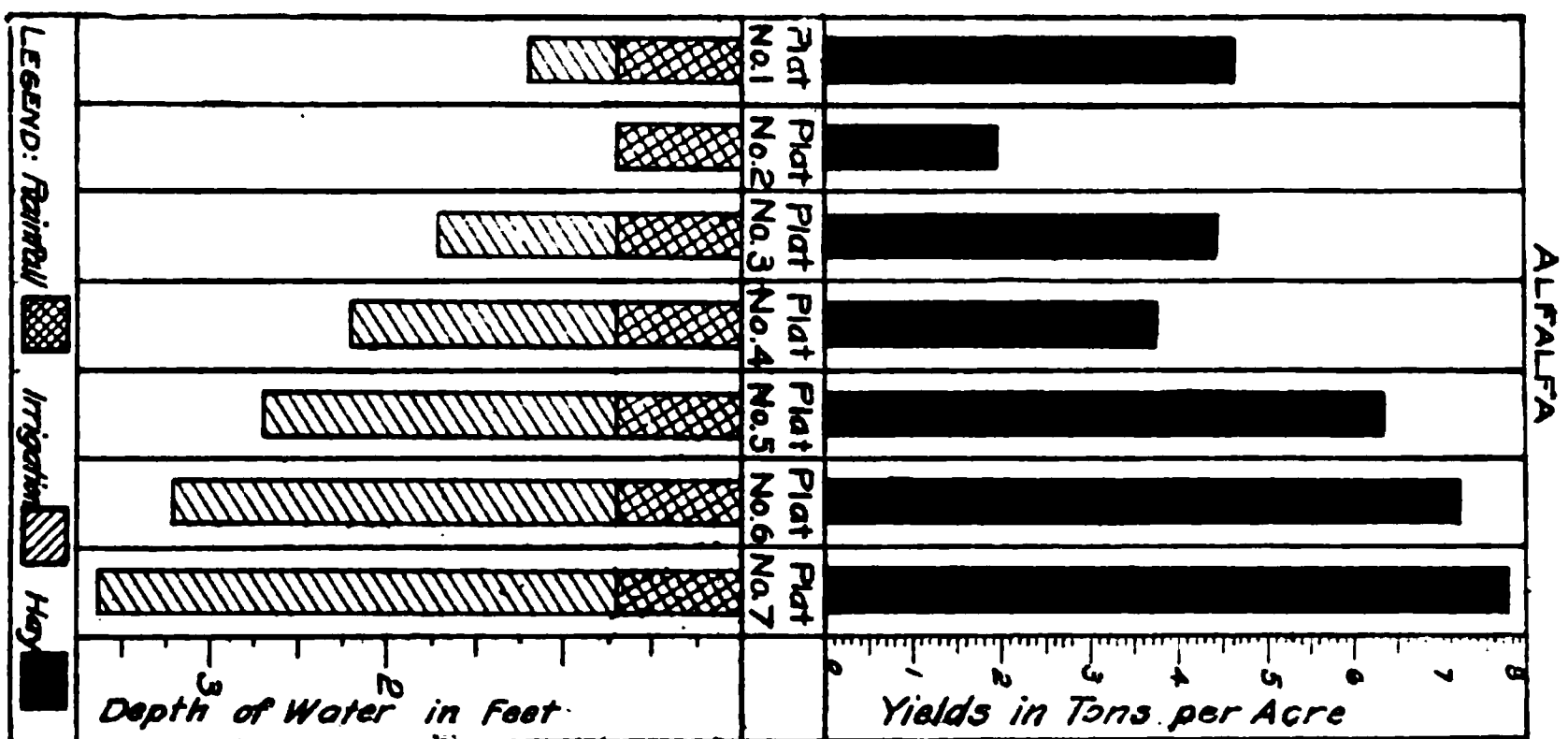


FIG. 3.

The grain was harvested on September 17, and the following were the heights and the yields with the total amount of water received, including the rainfall:

Plat Number	Depth of Water Received in feet	Yields in Pounds per acre	Height of Grain in feet
1	0.591	1920	3.17
2	1.091	2505	3.33
3	1.591	2655	3.33
4	2.091	2670	4.00
5	2.591	2715	4.67
6	3.091	2430	4.00

The wheat was irrigated too late in the season and that on plats Nos. 4, 5 and 6 was frost bitten and badly shrunk, which accounts for the small yields.

POTATOES.

The potatoes were planted on May 27, on six plats 12 by 242 feet, and containing one-fifteenth of an acre each. The times of irrigation are as follows:

First Irrigation July 16.

Plat Number	Depth of Irrigation in feet
1	0.000
2	0.000
3	0.000
4	0.250
5	0.500
6	0.667

Second Irrigation August 1.

Plat Number	Depth of Irrigation in feet
1	0.000
2	0.333
3	0.333
4	0.333
5	0.500
6	0.500

Third Irrigation August 10.

Plat Number	Depth of Irrigation in feet
1	0.000
2	0.167
3	0.333
4	0.333
5	0.333
6	0.333

Fourth Irrigation August 14.

Plat Number	Depth of Irrigation in feet
3	0.333
4	0.417
5	0.417
6	0.417

Fifth Irrigation August 20.

Plat Number	Depth of Irrigation in feet
4	0.167
5	0.250
6	0.333

Sixth Irrigation August 21.

Plat Number	Depth of Irrigation in feet
6	0.250

The following table shows the depths of water received, including rainfall, and the yields in pounds per acre :

Plat Number	Depth of Water Received in feet	Yields in Pounds
1	0.591	18,750
2	1.091	18,000
3	1.591	16,500
4	2.091	19,050
5	2.591	16,500
6	3.091	14,550

CO-OPERATION OF EXPERIMENT STATION AND U. S. DEPARTMENT OF AGRICULTURE, AND DUTY OF WATER UNDER CANALS.

For several years past the Irrigation Department of the Experiment Station has co-operated with the Irrigation Investigations of the U. S. Department of Agriculture in investigating various phases of the subject of irrigation. The duty of water, seepage losses from canals, return seepage to rivers, methods of division and distribution of water, methods of measuring etc. have been studied to some extent. This work has been continued during the past year, and its scope extended to investigating Fall

and Winter irrigation, construction of small reservoirs, rise and fall of ground water, water rights etc.

These investigations will all be published as a bulletin of this Station and will be embodied in a report of irrigation conditions in Montana, by the Irrigation Investigations.

The duty of water during the past season was taken up in Ravalli county, Jefferson county, Gallatin county and Yellowstone county.

In Ravalli, the investigations embraced the farm and orchard of Mr. W. B. Harlan in the upper end of the valley, the Bitter Root Stock farm of the late Marcus Daly, comprising an area of about 15,000 acres in the upper central portion, Bass Brothers' farm and orchard in the lower central portion, comprising an area of about 700 acres, and Chas. M. Allen's, Mrs. Dr. Mills' and Mrs. Hughes' farms and orchards in the extreme lower section of the valley.

In Jefferson county the duty was determined on the farm of Hon. T. T. Black, near Parrot. This being the first year that the land had been cultivated furnished us with valuable data on new land.

In Gallatin county the duty was determined on the Middle Creek Canal, the Cameron Ditch, and several small fields.

In Yellowstone county a transit and stadia survey was made of the entire area irrigated by the Big Ditch. The flow of water was also recorded during the season.

The following table gives the duty of water under canals for several years including the year of 1903:

Table No. VI.

Year	Canal	County	Area Irriga- ted	Water Used	Water Applied		
			Acres	Acre Feet	In Depth over Surface — Feet	In Acres per cu. foot per sec.	In Acres per Miners Inch
1901	Big Ditch	Yellowstone ..	18144	46501	2.56	85	2.13
1902	“ “	“ ..	20038	73165	3.65	76	1.90
1903	“ “	“ ..	17172	69932	4.07	58	1.45
1901	Republican	Ravalli	4105	13758	3.35	81	2.02
1902	“	“	4850	17856	3.68	89	2.22
1903	“	“	4850	19112	3.94	78	1.95
1901	Hedge	“	5260	20883	3.97	65	1.64
1902	“	“	5420	31274	5.76	58	1.46
1903	“	“	5420	23373	4.31	64	1.60
1901	Ward	“	3587	8626	2.41	112	2.81
1902	“	“	3985	9933	2.49	132	3.30
1903	“	“	3985	11785	2.96	62	1.55
1901	Skalkaho	“	1600	7494	4.68	56	1.40
1902	“	“	1975	13423	6.79	48	1.21
1903	“	“	1975	11630	5.89	36	.90
1901	Gird	“	1211	1759	1.45	102	2.56
1902	“	“	1345	4710	3.50	81	2.04
1903	“	“	1345	5120	3.81	54	1.35
1899	Middle Creek	Gallatin	3853	8074	2.10	87	2.19
1900	“ “	“	3853	7324	1.90	110	2.75
1901	“ “	“	3196	7454	2.34	90	2.26
1902	“ “	“	4828	5577	1.15	151	3.78
1903	“ “	“	4828	7137	1.478	151	3.78

DISCHARGE OF THE PRINCIPAL RIVERS OF THE STATE.

For several years past the Irrigation Department of the Station has supervised the work of measuring the disharge of the principal streams of the state for the Hydrographic branch of the U. S. Geological Survey.

Since the inauguration of the reclamation service of the same survey, the continuous services of an engineer have been necessary, which made it impossible for a Station officer to supervise the work.

The names of the rivers measured and the points of measuring are given in the ninth annual report, and the daily discharges of the same.

Through the kindness of Mr. F. H. Newell, chief engineer of the reclamation service, and his associates, Mr. C. C. Babb and others, we are permitted to publish the discharges of the rivers of the state for 1902 and 1903.

The following tables show the maximum, minimum and mean monthly discharge in cubic feet per second, the total number of acre-feet per month and for the period of observation, and the amount of water which ran from each square mile of the drainage basins during each month and for the year.

One cubic foot per second, or second-foot, is equivalent to 40 Montana miner's inches. One acre-foot is equal to 43,560 cubic feet, or is the quantity of water which would cover an acre of level surface to a depth of one foot.

The number of acres of land which could be irrigated by the water of any stream may be found by dividing the number of acre-feet during the irrigation period by 2. For example, take the Milk river at Malta, and assume the irrigation period to extend from June 1st to August 31st. The number of acre-feet of water is 67,597 plus 25,087 plus 25,640, which equals 118,324. This divided by 2 equals 59,162, which is approximately the number of acres of land that could be irrigated by the water of Milk river at that point during the months mentioned.

Again, suppose all the water of the same stream could be stored and used as necessity demanded. The total number of acre-feet for the year 1903 is 404,076. This divided by 2 would equal 202,038 acres. So the value of these tables is made apparent in giving, with a few minutes' computation, the approximate area that can be reclaimed by any of the streams herein mentioned.

Estimated Monthly Discharge of St. Mary River at International Line.
(Drainage Area 452 Square Miles.)

Month	Discharge in Sec.-Ft.			Total in Acre-Ft.	Run-Off	
	Maxi- mum	Mini- mum	Mean		Sec.-Ft. Per Sq. Mile	Depth in Inches
1902						
September (a).....	760	175	607	33118	1.343	1.503
October (b).....	610	295	475	29206	1.051	1.211
November.....	410	150	336	19993	0.743	0.823
December.....	1800	240	1105	67943	2.444	2.814
The period.....				153260		
1903						
January (d).....	1112	575	862	53002	1.907	2.198
February (e).....	1165	410	921	51150	2.038	2.122
March (f).....	3280	840	1327	81594	2.936	3.385
April.....	3020	360	1106	65812	2.447	2.728
May (g).....	3670	880	1875	115290	4.148	4.781
June (h).....	7180	4840	6116	363927	13.531	15.100
July (i).....	5740	2000	3424	210535	8.575	8.734
August (j).....	2000	1112	1426	87682	3.154	3.634
September (k).....	2630	720	1145	68133	2.533	2.823
October (l).....	1720	575	928	57061	2.053	2.363
November.....	880	360	536	31894	1.185	1.326
December.....	682	275	436	26809	0.965	1.116
The year.....	7180	275	1675	1212889	3.706	50.310

(a) 1 to 3 estimated; (b) 5 to 11 estimated; (d) 9 to 11 estimated; (e) 2 to 18 estimated; (f) 13, 19, 20 and 21 estimated; (g) 10, 11, 18 and 19 estimated; (h) 11 and 15 estimated; (i) 3, 5, 6 and 20 estimated; (k) 6 estimated; (e) 8, 9 and 17 estimated.

Estimated Monthly Discharge of St. Mary River at Dam Site, Mont.
(Drainage Area 177 Square Miles.)

1903						
January.....	140	46	66	4058	0.373	0.430
February.....	46	46	46	2555	0.259	0.270
March.....	46	37	40	2460	0.226	0.261
April.....	225	46	106	6307	0.598	0.669
May.....	2110	225	750	46116	4.237	4.883
June.....	3640	2110	3154	187676	17.819	19.886
July.....	3280	1160	1832	112645	10.350	11.934
August.....	1160	690	864	53125	4.881	5.621
September.....	1160	480	653	38854	3.689	4.120
October.....	1090	480	638	39229	3.604	4.154
November.....	480	310	398	23683	2.248	2.509
December.....	352	310	321	19737	1.814	2.095
The year.....	3640	37	739	536445	4.175	56.832

Estimated Monthly Discharge of Swift Current River at Henkel's Ranch, Montana (nearest post office, Wetzel). (Drainage Area 101 Square Miles).

Month	Discharge in Sec.-Ft.			Total in Acre Ft.	Run-Off	
	Maximum	Minimum	Mean		Sec.-Ft. Per Sq. Mile	Depth in Inches
1903						
January.....	67	45	50	3074	0.50	0.58
February.....	52	45	46	2555	0.46	0.48
March.....	78	45	50	3074	0.50	0.58
April.....	215	40	81	4820	0.80	0.89
May.....	980	113	335	20598	3.32	3.83
June (a).....	2740	1190	1902	113177	18.83	21.03
July.....	1120	425	734	45132	7.27	8.38
August.....	490	321	391	24042	3.87	4.46
September.....	1330	189	422	25111	4.18	4.66
October.....	560	189	275	16909	2.72	3.14
November.....	770	129	264	15709	2.61	2.91
December (d).....	215	147	170	10453	1.68	1.94
The year.....	2740	40	393	284654	3.90	52.88

(a) 8 to 16 estimated; (d) 11 to 31 estimated.

Estimated Monthly Discharge of Milk River at Havre, Mont.
(Drainage Area 7300 Square Miles.)

1903						
January.....			(a) 200	12298	.027	.031
February.....			(a) 200	11107	.027	.028
March.....			(a) 240	14757	.033	.038
April.....	1620	620	996	59266	.136	.152
May.....	4120	285	1079	66344	.148	.171
June.....	2820	507	975	58015	.134	.150
July.....	795	168	445	27362	.061	.070
August.....	795	145	378	23242	.052	.060
September.....	339	118	164	9759	.022	.024
October.....	195	110	138	8485	.018	.021
November.....			(a) 115	6843	.016	.018
December.....			(a) 147	9038	.020	.023
The year.....			423	306516	.058	.786

(a) Estimated.

Estimated Monthly Discharge of Milk River at Malta, Mont.
(Drainage Area 14044 Square Miles.)

Month	Discharge in Sec.-Ft.			Total in Acre-Ft.	Run-Off	
	Maxi- mum	Mini- mum	Mean		Sec.-Ft. Per Sq. Mile	Depth in Inches
1903						
January.....			(a) 220	13527	.015	.017
February.....			(a) 220	12218	.015	.016
March.....			(a) 380	23365	.027	.031
April.....	3355	830	1769	105263	.126	.141
May.....	3890	380	1350	83008	.096	.111
June.....	4170	275	1136	67597	.081	.090
July (d).....	710	150	408	25087	.029	.033
August (c).....	770	185	417	25640	.030	.035
September.....	770	185	299	17792	.021	.023
October.....	228	150	180	11068	.013	.015
November.....	228	86	145	8628	.010	.010
December.....	490	86	177	10883	.013	.015
The year.....			558	404076	.040	.537

(a) Estimated; (d) 30 and 31 estimated; (c) 1 to 7 estimated.

Estimated Monthly Discharge of Marias River at Shelby, Mont.
(Drainage Area 2610 Square Miles.)

1903						
January.....	1240	408	968	59520	.371	.431
February.....	1600	460	934	51871	.358	.373
March.....	7400	895	1563	96105	.598	.689
April.....	6800	518	1516	90208	.581	.651
May.....	3800	1100	2582	158761	.989	1.140
June.....	7800	3600	5467	325309	2.094	2.334
July (a).....	3800	800	1993	122545	.764	.882
August (b).....	800	510	671	41258	.257	.296
September (c).....	1240	460	618	36774	.237	.264
October.....	895	582	738	45378	.282	.325
November.....	2400	408	1048	62360	.401	.451
December.....	2200	654	1506	92600	.577	.668
The year.....	7800	408	1634	1182689	.626	8.504

(a) 12 to 23 and 25 to 31 estimated; (b) 1 to 17 and 19 to 31 estimated; (c) 1 to 10 estimated.

Estimated Monthly Discharge of Missouri River at Townsend, Mont.
(Drainage Area 14500 Square Miles.)

Month	Discharge in Sec.-Ft.			Total in Acre-Ft.	Run-Off	
	Maxi- mum	Mini- mum	Mean		Sec.-Ft. Per Sq. Mile	Depth in Inches
1903						
March 15-31.....	14425	4600	10568	356342	.729	.461
April.....	7760	3950	5295	315074	.365	.407
May.....	10655	5600	7590	466691	.523	.603
June.....	21445	6635	15785	939273	1.089	1.215
July.....	7760	3315	5282	324777	.364	.420
August.....	3630	1800	2398	147447	.165	.190
September.....	2745	1800	2350	139835	.162	.181
October.....	3315	2745	3231	198666	.223	.257
November (a).....	3315	2745	2934	174585	.202	.225
December (d).....			2745	168783	.189	.218
The period.....				3231473		

(a) 11 to 28 estimated; (d) 1 to 31 estimated.

Estimated Monthly Discharge of Missouri River at Cascade, Mont.
(Drainage Area 18295 Square Miles.)

1902						
July 17-31.....	6900	3170	4847	144208	.265	.148
August.....	2950	1810	2171	133490	.119	.137
September.....	2305	1915	2057	122400	.112	.125
October.....	2950	2380	2720	167247	.149	.172
November.....	4030	2550	3176	188985	.174	.194
The period.....				756330		
1903						
April.....	9300	4730	6536	388919	.357	.398
May.....	12700	7700	9958	612293	.544	.624
June.....	22700	12100	17953	1068278	.981	1.091
July.....	12700	2845	7302	448983	.399	.460
August.....	5305	2090	2591	159314	.142	.164
September.....	2550	1970	2274	135312	.124	.138
October.....	3170	2645	3056	187906	.167	.193
November.....	6300	3170	4177	248549	.228	.254
December.....	9900	2740	6083	374029	.332	.383
The period.....				3623583		

Estimated Monthly Discharge of Gallatin River at Logan, Mont.
(Drainage Area 1805 Square Miles.)

Month	Discharge in Sec -Ft.			Total in Acre-Ft.	Run-Off	
	Maxi- mum	Mini- mum	Mean		Sec.-Ft Per Sq. Mile	Depth in Inches
1903						
January.....	2320	480	824	50666	.456	.525
February.....	1520	530	1041	57814	.577	.601
March.....	1790	530	788	48452	.436	.502
April.....	1220	710	872	51888	.483	.538
May.....	2635	860	1515	93154	.839	.967
June.....	5030	2320	3749	223080	2.077	2.318
July.....	2570	500	1181	72616	.654	.754
August.....	650	382	467	28714	.259	.299
September.....	590	382	468	27848	.259	.289
October.....	780	620	712	43778	.394	.454
November.....	4580	650	1527	90862	.846	.944
December.....	1735	590	840	51650	.465	.536
The year.....	5030	382	1165	840622	.645	8.727

Estimated Monthly Discharge of West Gallatin River at Salesville, Mont.
(Drainage Area 860 Square Miles.)

1903						
January.....	380	360	369	22689	.429	.494
February.....	470	365	382	21215	.444	.462
March.....	440	360	370	22750	.430	.496
April.....	660	365	429	25527	.499	.556
May.....	2700	440	1066	65546	1.240	1.430
June.....	5325	2850	4125	245454	4.800	5.350
July.....	2850	1020	1635	100532	1.901	2.191
August (a).....	1430	470	684	42058	.795	.916
September.....	510	415	456	27134	.530	.590
October.....	510	440	463	28469	.538	.619
November.....	470	370	422	25111	.491	.551
December.....	470	370	428	26317	4.98	.574
The year.....	5325	360	902	652802	1.050	14.229

(a) 17 to 31 estimated.

Estimated Monthly Discharge of Madison River at Norris, Mont.
(Drainage Area 2085 Square Miles.)

Month	Discharge in Sec.-Ft.			Total in (Acre-Ft.	Run-Off	
	Maxi- mum	Mini- mum	Mean		Sec.-Ft. Per Sq. Mile	Depth in Inches
1903						
January (a)			1300	79934	.624	.714
February (a)			1300	72198	.624	.650
March (a)			1300	79934	.624	.714
April	1700	1440	1622	96516	.778	.869
May	3355	1700	2281	140253	1.090	1.260
June	6145	3510	5065	301389	2.430	2.710
July	3510	1700	2141	131645	1.030	1.190
August	1440	1050	1258	77351	.603	.693
September	1220	1050	1095	65157	.525	.586
October	1220	1050	1209	74338	.580	.670
November	1220	1220	1220	72595	.585	.646
December (a)			1200	73785	.576	.667
The year			1749	1265095	.839	11.369

(a) Estimated.

Estimated Monthly Discharge of Jefferson River at Sappington, Mont.
(Drainage Area 8984 Square Miles.)

1903						
January	2470	1330	1797	110493	.200	.22
February	4020	1890	2848	158169	.320	.33
March	2320	1750	1974	121376	.22	.25
April	4020	1890	2561	152390	.28	.31
May	5630	3070	3654	224675	.41	.47
June	9770	4020	7117	423491	.79	.88
July	4020	1470	2412	148308	.27	.31
August	1470	570	858	52817	.10	.12
September	1060	570	829	49269	.09	.10
October	1330	940	1202	73908	.13	.15
November	6435	1190	3204	190651	.36	.40
December	5515	1260	2712	166754	.30	.35
The year	9770	570	2597	1872301	.29	3.89

**Estimated Monthly Discharge of Yellowstone River at Livingston, Mont.
(Drainage Area 3580 Square Miles.)**

Month	Discharge in Sec.-Ft.			Total in Acre-Ft.	Run-Off	
	Maxi- mum	Mini- mum	Mean		Sec.-Ft Per Sq. Mile	Depth in Inches
1903						
January.....	1280	960	1152	70834	.322	.371
February (a).....	1200	880	1087	60369	.304	.317
March.....	1320	1060	1185	72863	.331	.382
April.....	2150	1200	1436	85448	.401	.447
May.....	7480	1585	3236	198974	.904	1.040
June.....	20400	10770	15711	934870	4.390	4.900
July.....	13120	5400	8481	521476	2.370	2.730
August.....	5540	2830	3852	236850	1.080	1.250
September.....	2800	2290	2521	150010	.704	.784
October.....	2500	1830	2155	132506	.602	.694
November (c).....	1890	1450	1673	99550	.467	.521
December (d).....	1950	1200	1462	89895	.408	.470
The year.....	20400	880	3662	2653645	1.024	13.906

(a) 14 to 18 estimated; (c) 15 to 25, also 29 estimated; (d) 6 estimated.

**Estimated Monthly Discharge of Bitter Root River at Grantsdale, Mont.
(Drainage Area 1550 Square Miles.)**

1903						
January ..	700	395	518	31850	.334	.385
February ..	530	395	471	26158	.304	.317
March	1150	340	519	31912	.335	.386
April	3050	615	1409	83841	.909	1.010
May	6150	1745	3031	186369	1.955	2.256
June	12875	4575	7968	474129	5.141	5.736
July	3700	700	1912	117564	1.234	1.424
August.....	700	175	334	20537	.215	.248
September	1150	150	481	28622	.310	.346
October.....	1585	460	825	50727	.532	.617
November.....	790	530	615	36596	.397	.443
December.....	1020	530	650	39967	.419	.483
The year	12875	150	1561	1128272	1.007	13.651

Estimated Monthly Discharge
(Drainage)

Month

1903

January (a)
February (a)
March
April
May
June
July
August
September (a)
October (a)
November (a)
December (a)
The year

(a) Estimated.

Estimated Monthly Discharge
(Drainage)

1903

May 15—31
June (a)
July
August
September
October
November
December
The period

(a) 21 to 27 estimated.

The following is a list of discharge measurements of many of the principal streams throughout the state:

Date.	Stream	Locality	Dis-charge Sec.-Ft.
1903			
May 11.....	St. Mary's.....	International Line.....	1131
May 11.....	" ".....	" ".....	1125
June 5.....	" ".....	" ".....	6942
June 23.....	" ".....	" ".....	5212
August 3.....	" ".....	" ".....	1730
October 5.....	" ".....	" ".....	1325
May 10.....	" ".....	Dam Site.....	484
June 3.....	" ".....	" ".....	2431
June 18.....	" ".....	" ".....	3683
June 25.....	" ".....	" ".....	2756
June 30.....	" ".....	" ".....	3418
July 6.....	" ".....	" ".....	2212
July 8.....	" ".....	" ".....	2082
July 14.....	" ".....	" ".....	1831
July 18.....	" ".....	" ".....	1638
July 25.....	" ".....	" ".....	1574
July 31.....	" ".....	" ".....	1246
August 8.....	" ".....	" ".....	909
August 14.....	" ".....	" ".....	841
August 22.....	" ".....	" ".....	801
August 27.....	" ".....	" ".....	758
September 2.....	" ".....	" ".....	619
September 26.....	" ".....	" ".....	979
October 3.....	" ".....	" ".....	995
October 10.....	" ".....	" ".....	637
October 17.....	" ".....	" ".....	664
August 22.....	Kennedy Creek..	Head of Upham Ditch.....	114
October 3.....	" ".....	" ".....	102
October 10.....	" ".....	" ".....	84
May 9.....	Swift Current....	Henkle's Ranch, Mont...	430
June 3.....	" ".....	" ".....	2473
June 20.....	" ".....	" ".....	1546
June 26.....	" ".....	" ".....	1260
July 3.....	" ".....	" ".....	1030
July 9.....	" ".....	" ".....	964
July 18.....	" ".....	" ".....	745
July 25.....	" ".....	" ".....	718
August 1.....	" ".....	" ".....	500
August 8.....	" ".....	" ".....	411
August 15.....	" ".....	" ".....	407
August 22.....	" ".....	" ".....	358
August 27.....	" ".....	" ".....	413
September 26.....	" ".....	" ".....	1206
October 3.....	" ".....	" ".....	344
October 10.....	" ".....	" ".....	292
October 17.....	" ".....	" ".....	338
April 25.....	Milk.....	Malta, Mont.....	1073
May 12.....	".....	" ".....	291
May 14.....	".....	" ".....	127

Date	Stream	Locality	Dis-charge Sec.-Ft.
1903			
May 14.....	Milk.....	Malta Mont.....	464
May 24.....	".....	".....	3729
May 28.....	".....	".....	2777
June 2.....	".....	".....	4184
June 9.....	".....	".....	1753
June 16.....	".....	".....	618
June 22.....	".....	".....	399
June 23.....	".....	".....	501
July 8.....	".....	".....	357
July 15.....	".....	".....	479
July 21.....	".....	".....	266
July 21.....	".....	".....	271
August 12.....	".....	".....	483
August 12.....	".....	".....	496
September 8.....	".....	".....	150
October 8.....	".....	".....	73
November 6.....	".....	".....	148
November 12.....	".....	".....	130
November 26.....	".....	".....	88
December 7.....	".....	".....	97
December 10.....	".....	".....	107
April 4.....	".....	Havre, Mont.....	1130
April 13.....	".....	".....	1034
April 22.....	".....	".....	895
April 24.....	".....	".....	912
April 24.....	".....	".....	842
May 4.....	".....	".....	588
May 13.....	".....	".....	599
May 13.....	".....	".....	552
May 16.....	".....	".....	388
May 25.....	".....	".....	1736
May 27.....	".....	".....	1987
May 28.....	".....	".....	2784
May 29.....	".....	".....	3705
May 30.....	".....	".....	4135
June 24.....	".....	".....	483
July 23.....	".....	".....	208
July 24.....	".....	".....	152
July 28.....	".....	".....	279
August 18.....	".....	".....	288
August 28.....	".....	".....	974
September 29.....	".....	".....	118
November 4.....	".....	".....	107
July 22.....	Beaver Creek.....	Ashfield, Mont.....	60
August 16.....	".....	".....	22
September 12.....	".....	".....	.5
July 21.....	".....	Overflow, Bourdoin, Mont.....	14.1
August 10.....	".....	".....	.2
June 27.....	Harlem Canal.....	Zurich, Mont.....	31.1
July 27.....	".....	".....	31.2
July 27.....	".....	".....	31.4
August 19.....	".....	".....	4.0
June 26.....	Paradise Val Can.....	Chinook, Mont.....	16.8

Date	Stream	Locality	Dis-charge Sec.-ft.
1903			
August 20.....	Paradise Val. Can	Chinook, Mont.....	.5
June 28.....	Belknap Canal...	" ".....	87
July 25.....	" ".....	" ".....	76
August 21.....	" ".....	" ".....	.8
May 7.....	Marias.....	Shelby, Mont.....	1721
May 30.....	".....	" ".....	3330
June 25.....	".....	" ".....	3969
July 24.....	".....	" ".....	1019
August 18.....	".....	" ".....	617
October 1.....	".....	" ".....	786
May 15.....	Missouri.....	Cascade, Mont.....	7729
June 18.....	".....	" ".....	19186
July 8.....	".....	" ".....	8936
July 22.....	".....	" ".....	5054
July 23.....	".....	" ".....	5189
August 28.....	".....	" ".....	2317
October 2.....	".....	" ".....	2840
November 3.....	".....	" ".....	2786
April 19.....	".....	Townsend, Mont.....	5173
April 30.....	".....	" ".....	7020
May 29.....	".....	" ".....	7786
June 20.....	".....	" ".....	15679
July 6.....	".....	" ".....	8104
July 23.....	".....	" ".....	4550
August 24.....	".....	" ".....	2029
September 27.....	".....	" ".....	2649
April 18.....	Gallatin.....	Logan, Mont.....	663
May 2.....	".....	" ".....	935
May 27.....	".....	" ".....	1182
May 28.....	".....	" ".....	1349
May 30.....	".....	" ".....	1552
June 6.....	".....	" ".....	4013
June 21.....	".....	" ".....	3295
July 9.....	".....	" ".....	1496
July 23.....	".....	" ".....	788
August 24.....	".....	" ".....	309
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May 27.....	".....	" ".....	3051
June 7.....	".....	" ".....	9755
June 22.....	".....	" ".....	5968
July 10.....	".....	" ".....	3436
July 24.....	".....	" ".....	1874
August 24.....	".....	" ".....	535
October 4.....	".....	" ".....	779
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May 23.....	".....	" ".....	2206
June 11.....	".....	" ".....	5983
June 26.....	".....	" ".....	3793
July 15.....	".....	" ".....	2183
September 4.....	".....	" ".....	1306
October 16.....	".....	" ".....	1185

Date	Stream	Locality	Dis-charge Sec.-Ft.
1903			
April 17	Middle Creek	Bozeman, Mont.	26.7
May 21	" "	" "	89
June 3	" "	" "	503
June 13	" "	" "	348
June 28	" "	" "	326
July 17	" "	" "	280
September 6	" "	" "	60
October 14	" "	" "	48
January 3	West Gallatin	Salesville, Mont.	375
April 18	" "	" "	402
May 22	" "	" "	929
June 13	" "	" "	5006
June 28	" "	" "	3063
July 16	" "	" "	1604
September 5	" "	" "	474
October 15	" "	" "	448
April 26	Big Blackfoot	Bonner, Mont.	2352
May 23	" "	" "	2979
June 29	" "	" "	3830
July 13	" "	" "	2003
September 13	" "	" "	948
October 8	" "	" "	888
April 24	Missoula	Missoula, Mont.	3776
June 30	" "	" "	6580
July 13	" "	" "	3661
September 12	" "	" "	1670
October 6	" "	" "	1836
April 25	Bitterroot	" "	4131
May 23	" "	" "	3377
June 1	" "	" "	9982
June 15	" "	" "	12637
June 29	" "	" "	9121
July 12	" "	" "	4217
August 10	" "	" "	1546
September 13	" "	" "	1463
October 8	" "	" "	1683
April 28	" "	Grantsdale, Mont.	3283
May 29	" "	" "	4768
June 16	" "	" "	9075
June 24	" "	" "	3914
July 9	" "	" "	2308
August 14	" "	" "	322
September 9	" "	" "	338
October 9	" "	" "	647
August 1	Yellowstone	Glendive, Mont.	31058
August 31	" "	" "	9645
September 28	" "	" "	7131
October 31	" "	" "	5966
April 4	" "	Livingston, Mont.	1424
May 25	" "	" "	2549
June 24	" "	" "	54208
July 3	" "	" "	11763
July 20	" "	" "	7563
September 1	" "	" "	3009

ACKNOWLEDGMENTS.

The writer is indebted to Prof. Samuel Fortier, irrigation engineer, who planned the work for the past year and to Wm. McKee, who did the field work on the Station farm, and to Messrs. Chas. D. Flaherty, Frank Tavenner, Garfield Morris, James H. Sloan, Lewis A. Cowan, Ed. D. Kinney, Jerome G. Locke and Stanley Yergey, who have assisted in field work and computations.

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

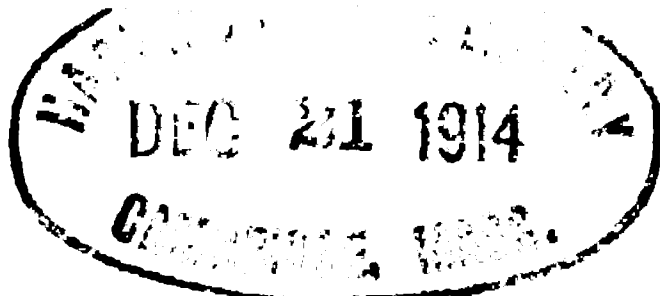
F. B. LINFIELD, DIRECTOR

**ELEVENTH ANNUAL
REPORT**

**FOR
THE FISCAL YEAR ENDING
JUNE 30TH. 1904**

BOZEMAN, MONTANA

**DECEMBER
1904**



**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION**

BOZEMAN, MONTANA

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F. B. LINFIELD, B. S. A., *Director and Agriculturist.*
J. W. BLANKINSHIP, Ph. D., *Botanist.*
R. A. COOLEY, B. Sc., *Entomologist.*
V. K. CHESNUT, B. Sc., *Chemist.*
J. S. BAKER, B. S., *Irrigation Engineer.*
R. W. FISHER, B. S., *Horticulturist.*
JAMES DRYDEN, *Poultryman.*
EDMUND BURKE, *Assistant Chemist.*
W. J. ELLIOTT, B. S. A., *Assistant Dairyman.*
ALFRED ATKINSON, B. S. A., *Assistant Agronomist.*
H. J. REESE, B. S., *Assistant Chemist.*

Postoffice, Express and Freight Station, Bozeman.
All communications to the Experiment Station should be addressed to

THE MONTANA EXPERIMENT STATION,
Bozeman, Montana.

NOTICE--The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

LETTER OF TRANSMITTAL.

Bozeman, Montana, December, 31, 1904.

To His Excellency, JOSEPH K. TOOLE,
Governor of Montana.

Dear Sir:—In accordance with the Congressional Act of March 2, 1887, I have the honor to transmit herewith the eleventh annual report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1904, the results of investigations of the several departments are reported to the end of the State year, November 30, 1904.

Very respectfully,

F. B. LINFIELD.

Director. •

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REPORT OF THE TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1903-1904.

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1904, as per Act of Congress approved March 2, 1887..\$15,000.00

Cr.

By Salaries	\$ 8,439.00
Labor	1,978.48
Publications	2,932.41
Postage and stationery	341.42
Freight and express	337.58
Heat, light, water and power.....	60.94
Chemical supplies	196.92
Seeds, plants and sundry supplies.....	195.64
Fertilizers	12.50
Library	
Tools, implements and machinery	287.97
Furniture and fixtures	110.81
Scientific apparatus	91.01
Contingent expenses	15.00

Total\$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1904; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been 15,000.00, and the corresponding disbursements \$15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Attest:

PETER KOCH,

Custodian.

Signed:

WALTER S. HARTMAN,

PETER KOCH,

Auditors.

SUPPLEMENTARY STATEMENT.

EXPERIMENT STATION MISCELLANEOUS FUND.

To Receipts Farm produce, etc.....	\$3871.02
By Salaries	\$
Labor	742.25
Publications	
Postage and stationary.....	
Freight and express.....	
Heat, light and water.....	
Chemical supplies	204.88
Seeds, plants and sundry supplies.....	307.51
Fertilizers	
Feeding stuffs.. ..	217.38
Library.....	
Tools, implements and machinery.....	
Furniture and fixtues.....	
Scientific apparatus	
Live stock	1737.36
Traveling expenses ,.....	373.33
Contingent expenses	
Buildings and repairs., ..	288.31

REPORT OF THE DIRECTOR.

IMPROVEMENTS.

The past year while in a measure a period of reorganization of the station was marked by substantial progress in the work done and in added equipment for that work.

The funds appropriated by the legislature of 1903 for farm buildings have provided us with excellent facilities for caring for our dairy and breeding cattle and the experimental grains and seeds. Illustrations and descriptions of these buildings will accompany this report. The ground around these new buildings has been leveled and graded and three corrals provided for the proper care of the live stock.

From the maintenance fund provided by the state, we have been able to add an incubator cellar and to finish the brooder house of the poultry building and also to provide for heating for the same. During the coming season it is planned to enlarge materially the accommodations for the poultry.

From several old buildings with a little new lumber a very convenient piggery has been constructed. This building consists, first; of a center part 30 feet by 35 feet which is used for feed storage, farrowing pens and a room to be used for killing and dressing animals. From this center part run two wings 50 by 16 feet, one wing to the west and the other to the south, giving six pens in each 8 by 12 feet with an alley four feet wide along one side. Outside of each pen is a yard 8 by 15 feet. This has made us 12 excellent feeding pens for the hogs.

Considerable yet remains to be done to get the farm in first class shape and we plan to continue the work of improvement for the next two years as far as our limited funds will permit. The roads on and around the farm yet need some additional work. A

beginning has been made in draining the swamp in the pasture, and this work we plan to continue till all the land is reclaimed.

During the past summer a herd of dairy cows was purchased so that we are now in a position to take up the dairy question and to study the problem of milk production.

THE WORK OF THE DEPARTMENTS.

All of the departments have taken hold of the problems before them with vigor, and a large amount of valuable work has been done.

The chemical department has excellent facilities for its work and an additional assistant added last spring has placed this department on a strong basis. The main line of work by the department has been the study of the so-called loco poisoning of sheep presumably caused by the loco weed. This work was undertaken in co-operation with the Bureau of Plant Industry, U. S. Department of Agriculture. No definite conclusions can yet be drawn from this work but the investigation will be continued during the coming season. The department has also continued its study on food products but expects to concentrate in the future on the study of those adulterated products that come in competition with the Montana produced foods.

The publication of Bulletin No. 52 on sugar beets by the former head of the department, Dr. Traphagen seemed to have aroused renewed interest in the sugar beet investigations. The contemplated factory at Billings, which is also in a measure a result of the sugar beet studies at the Experiment Station, has added to the interest so that there is considerable call for further tests by the people in all parts of the state. The Chemical department will therefore, continue its investigations along this line.

The head of the Botanical Department was absent in the east for a considerable part of the past year making a study of the flora of the state which the department has been collecting for several years past. A set of Montana plants was also prepared for exhibition at the World's Fair at St. Louis.

During the latter part of the season some attention has been devoted to the study of plant diseases, to collecting seeds of possibly economic plant for the horticulturist and to the testing of the purity of grass and other seeds.

The Entomological Department has spent a very busy year.

With the development of the agriculture of the state, come the many insect enemies of the farmers' crops. Some of these come from without the state but finding here new climatic conditions, they adopt in a measure new habits of life, so that many well known insects become here a new problem to the entomologist. There are also many insects native to the state which seem to be very willing to leave the native vegetation and feed on the harvest prepared by man. These also have to be studied. The entomologist is devoting himself to the study of the life histories and habits of a number of these insect pests. With such knowledge it is generally possible to devise some method of control.

During the past year the eye-spotted bud moth has been studied and methods of practically complete control devised. The results are reported in Bulletin No. 55. The strawberry crown girdler has also been studied and considerable progress has been made in devising methods of combatting this pest. These results are also published in Bulletin No. 55. Much data has also been collected concerning the grasshopper, cabbage aphid and allied species, and other insects.

Considerable additions have been made to the insect collection of the department and a beginning has been made in the study of the native insectivorous birds.

The Horticultural Department has continued its observations during the year on the varieties of fruits and vegetables. There is a large field for work along this line particularly in the originating of new varieties better adapted to Montana conditions. Crosses have been made and a large number of seedlings started as a beginning in this new line of inquiry. This kind of work is slow, requiring years, generally, to bring satisfactory results, but observations show it to be the true method of finding improved varieties better adapted to Montana conditions.

The department has also started to make a collection of native shrubs and will study their adaptability for ornamental purposes.

Considerable of the time of the department has been given to clearing up the grounds, ridding it of overgrown nursery stock of all kinds and to planting the cleared ground to small and large fruits.

The Irrigation Department was reorganized during the year owing to the resignation of Prof. S. Fortier. But through the appointment of Mr. J. S. Baker who for several years assisted Prof.

Fortier in this work, the plans of Prof. Fortier were continued. Investigations were continued on the duty of water in the Bitter Root and Yellowstone valleys.

A new line of work was some studies in drainage on a tract of land near Billings, where, in co-operation with Mr. Ed O'Donnell and the Custer Cattle Co., a large tract of land was drained. Further observations will be made on the results.

At Wayne, Cascade Co., a small farmers' reservoir was constructed, and at Dillon plans were laid for the study of the effect of late fall and early spring irrigations.

The irrigation studies on the station farm and in the tanks were also continued.

The department has been co-operating with Prof. Elwood Mead of the Irrigation Division, U. S. Dept. of Agriculture and also with Mr. Wade, State Engineer. The extra funds provided have been a great help to the work of the department.

The Agricultural Department has aimed to continue the work in the field and with the livestock about on the basis of the past while at the same time preparing for an extension of these lines of work.

A car of steers and sheep were fed during the winter and a small herd of cows maintained.

In the spring an assistant for the field work, Mr. A. Atkinson of Iowa, was engaged and plans were laid for a considerable extension of the field work. Very much time was spent during the year in the study of the accumulated data from the field work which was buried in a mass of note books, and unfortunately very fragmentary in character. A system of record books for the field work was also devised. With the old data available for study we have a much better basis for our future work.

With the completion of the new cattle barn and the purchase of a herd of grade cows, a beginning has been made in the study of milk production. It also enlarges our facilities for study in the raising of young stock of all kinds.

During the year it was decided to extend the work with poultry and so an addition was made to the poultry building, affording room for feed, for a heater, and for incubators. A large number of chicks were also raised and several more strains purchased, so that we make a new start in this work. It was thought best to place this work in the hands of an expert and so Mr. James Dryden who for

many years had charge of the poultry at the Utah Experiment Station, was engaged to look after the work. It is planned to enlarge the plant in the near future so that it can be handled more economically.

With the help of the college the engine house of the dairy was enlarged and a fuel room and ice house built. This puts the dairy work on a well equipped basis though we already find that for student and station work the building is too small for our needs.

The department has also devoted considerable time and labor to improvements,—building a piggery, leveling and grading around buildings, fencing, draining, etc.

The head of the department, as the year before, had charge of the agricultural exhibit at St. Louis and this demanded nearly two months of his time away from the station, besides the demands of correspondence, etc., in connection with the work.

SUB-STATIONS.

In the spring of 1903 a 20 acre tract was selected by Prof. S. Fortier at Wayne Siding near Great Falls as a temporary sub-station. This work was undertaken in co-operation with Prof. Mead of the Division of Irrigation, U. S. Dept. of Agriculture. There were three objects kept in view; first, to test the methods of cultivation and kind of crops that would yield the best without irrigation; second, to determine how to construct a small reservoir to catch the flood water of the spring to be used later for watering stock and irrigating a small orchard and garden; third, to arrange to control the over-flow from the reservoir and turn it on the land to irrigate it early in the spring and late in the fall. During the past year the dam was built and a start was made in cropping the land.

Last fall a tract was secured from Mr. J. E. Morse of Dillon to test the efficiency of late fall and early spring irrigation on both cultivated crops and alfalfa.

There is room for considerable extension of this work in several parts of the state. Our valleys are so varied in their climatic conditions that there is necessity for more careful study of conditions governing crop growth in these several localities. This work cannot be undertaken, however, without additional funds from the state.

POLICY OF STATION.

The policy of the station in the future as in the past will be to deepen rather than extend the lines of work. No man can cover the whole field of agriculture and do work satisfactorily either to himself or to the people. The plan, therefore, will be to assign a man to each department of the work and as far as possible let him confine himself to that field. In several cases this will necessitate co-operation between various departments in the complete study of a problem but we believe that much more will be accomplished by such co-operation than for each department to cover the wider field. This it appeals to me is a point vital to our progress. We are not, and cannot organize on the basis of the large bureaus of the Agricultural Department at Washington, D. C., where each bureau may call to its aid and employ directly all the special scientists needed to fully elaborate the various lines of work undertaken. Our plan must be to let each department specialist handle the work in his field and when any department has to go outside of its special work, then to arrange co-operation with the other departments that are fitted to handle the special phases of the work that come in its province. Personal and even departmental consideration must at all times be secondary to the work of the station as a whole.

As time passes and the field work develops it is difficult, indeed, to keep the demands for work within the funds available. Efficiency and thoroughness must, however, be our aim even at the expense of leaving out some lines of work which may appear very necessary.

In a new and developing country it has seemed to me that, the positive side of the work should have most consideration. The creating of new and better forms and methods should in the main predominate over the combating of plant and animal enemies important as these latter are. To this end the policy has been and will be to develop the creative departments of the station.

It is not possible to exactly define the limits of the station work, but broadly speaking it will divide itself into four groups—three of these largely creative or positive and one negative in character.

The first will deal with the originating and testing of new varieties of plants and the study of improved methods of growing them. This will be the work of the Agronomist and the Horticulturist, together with the co-operation of the Chemist. This is truly a broad

and important field yet it is planned to keep it within limits that will warrant efficiency in results.

A second line, which in some respects in an arid country is more important than the first mentioned, is the study of the best use of water: The efficient use of water and the methods of management that will save the largest amount for the plant and reduce the waste to a minimum. This study will be carried on, on irrigated land and on the dry bench lands and calls for the co-operation of the Irrigation Engineer, the Agronomist and the Horticulturist.

The third problem will be a consideration of the relation of land and live stock. How to economically turn the crops of the farm into products that will sell readily and profitably. In this work all classes of live stock will be studied and the relative efficiency of each will be recorded. The best and most valuable work will be done by co-operation between the Animal Industry and Chemical Departments.

The fourth and negative side of our activities is a large and varied one. It has to do with the enemies of the farmer, the control of plant, insect and parasitic pests, and of the excess of mineral salts and water in the soil. Here then may be much independent investigation and some co-operative work. The chemist, the engineer, the biologist and the veterinarian will all have something to do in this group.

FARMERS' INSTITUTES.

The Director of the station is a member of the Board of Administrators of Farmers' Institutes and in the organization of the Board was made Secretary of the Board and Superintendent of Farmers' Institutes, with direct charge of the management of the institute work over the state.

The past year has called for a great deal of time in organizing this work. It has entailed a large amount of correspondence and several weeks' time on the road. Each member of the Station staff has also spent about two weeks or over in the work, and has rendered very efficient service. All parts of the state have been visited. Meetings have been held in every farming county and in nearly every valley in the state. These visits to various parts of the state have been of considerable value to the staff both for the college and sta-

tion work, and it has aided materially in bringing the results of our work immediately home to the people.

It is encouraging to note that the interest in these meetings over the state is growing rapidly. The attendance for the past year was more than double that of the previous year, and a larger number of communities are asking for meetings.

STATION STAFF.

There was but one change in the station staff the past year, but several additions and some advancements have been made. The station staff now numbers eleven compared to eight one year ago. This has meant an increase in the specialists in the technical agricultural field and also an increase in the assistants in some departments.

At the end of the fiscal year, July 1, Prof. S. Fortier who for three years was director of the station and irrigation engineer, severed his connection with the station to accept a position in California under the Irrigation Division of the U. S. Dept. of Agriculture. Prof. Fortier's wide experience in irrigation work brought a call from a larger field with increased remuneration, that he could not refuse.

Prof. Fortier had been absent on leave for one year, and the writer who had been acting director during that time was appointed to the position of director on Prof. Fortier's resignation. In addition to the duties of director, the writer also remained at the head of the agricultural work.

The vacancy in the irrigation department occasioned by Prof. Fortier's resignation was filled by the appointment of Prof. J. S. Baker as Irrigation Engineer. Prof. Baker had been Assistant Civil Engineer in the college and had spent several years in irrigation studies under Prof. Fortier's direction.

Because of the increased duties of the head of the Agricultural Department, Mr. Alfred Atkinson, a graduate of the Iowa Agricultural College, was elected to the position of Assistant Agronomist with immediate charge of the field crop work.

Mr. R. W. Fisher was advanced to the position of Horticulturist and given full charge of the horticultural work.

Mr. H. J. Reese, a graduate of the Chemical Department, was appointed as assistant in the chemical laboratory.

Later in the season Mr. James Dryden, who for many years had charge of the poultry work at the Utah Station, and who had made a wide reputation for himself and the station in this work was engaged to take charge of the poultry work. Mr. Dryden also had charge of the office as clerk and editor and is a valuable addition to the station staff.

NEEDS OF STATION.

A pressing need of the Station is more room. The cramped quarters in the present Experiment Station is used for College and Station work by five departments of the College and station besides the director's office, and the library and mailing room of the Experiment Station. When a building 45 by 50 feet, two stories with a basement and attic, has to accommodate all the technical agriculture and horticulture, the civil engineering, the botany and zoology, subjects, every one of which requires large laboratory room, it is surprising that so efficient work has been done in the past. These departments cannot do the work which is being demanded of them in these cramped quarters and it is hoped that this fact will be recognized by our legislators in the very near future and more commodious quarters provided.

A beginning has been made in providing increased room and facilities for our live stock and farm products. Ordinarily it might seem that we might be able to get along for a few years with these additions. When it is remembered, however, that two years ago there were no farm buildings of a permanent character on the place and the temporary shacks we have are not alone rough looking, but wholly inadequate for our work, it will be recognized that additions are yet needed and should be provided as soon as possible.

In this connection, sheep and steer feeding buildings are our greatest need, though a new horse barn and cottages for the foremen of the farm, livestock, poultry and orchard are needed as these men must be on the ground to give to their work the attention it demands.

CORRESPONDENCE.

The correspondence of the Station shows no diminution in

amount. In fact, all departments report an increase over previous years.

From the Director's office nearly 1,000 letters were received and answered. The Chemist sent out nearly 400 letters. The Entomologist 525, the Dairyman about 400, the Horticulturist 475, the Irrigation Engineer 300, the Poultryman about 200 in 7 months, the Botanical Department about 300, the Agronomy Department over 100 in 6 months.

This makes a total of about 3700 letters answered for the year by the various members of the Station staff. A very great number of these letters required extended answers and many required considerable research. These letters come from all parts of the state and cover all phases of agricultural practice.

The demands of this correspondence make the Station Staff an information bureau on agricultural topics and is a large tax on the time and energy of the various departments. It is, too, a tax for which little credit is frequently given as there is little to show in the way of results beyond the letter books and letter files. It is believed, however, that the returns to the people of the State amply compensate for this work, though the benefits cannot be measured.

PUBLICATIONS OF THE YEAR.

During the past year an attempt was made to improve the style of our publications. A committee of the staff prepared a new style-board, which it is believed will make our bulletin look much more neat and attractive. It is also planned to make each yearly volume of the bulletins uniform in style. It is believed that the improved appearance will commend itself to the people of the state, while the thousands that go beyond the state will certainly speak a better word for us.

During the year a smaller number of bulletins have been issued than in either of the two previous years. This was due in part to the fact that in some departments the data on hand has been published, and for other departments, the pressure of other duties has prevented the preparation of bulletins from the data accumulated for the past year or two. But four bulletins and one annual report have been published, making altogether 275 pages of printed matter.

The following is the list published for the year:

Bulletin No. 52, Sugar Beets:—This bulletin in addition to giving a report of the work with sugar beets for 1903, gives a summing up of the results of several years co-operative tests with sugar beets. The possibility and prospects for profitable sugar beet growing for a sugar factory are fully discussed. 56 pages.

Bulletin No. 53, Creameries and Cheese Factories:—Their Organization and Equipment: This gives plans and specifications for the building and equipment of creameries and cheese factories and rules for the organization of local companies for the management and running of the same. 32 Pages, 6 Plates.

Bulletin No. 54, The Alkali Soils of Montana:—This is a second bulletin on this subject, bringing the results of the work up to date. The origin, cure, and control of the alkali is discussed. 34 pages and 5 plates.

Bulletin No. 55, Second Annual Report of the State Entomologist:—Records the result of investigations of the eye-spotted bud moth, the strawberry crown girdler, the elm mealy bug, and gives remedies for the same. It discusses also a lot of insect pests that are liable to become injurious in Montana. 75 pages. 3 Plates.

The Eleventh Annual Report, 96 pages 6 plates.

LIST OF STATION PUBLICATIONS.

1. Organization—Announcements.
2. Smut of Wheat, Oats and Barley.
- * 3. Pig Feeding.
4. Glanders.
- * 5. First Annual Report, Crop Statistics of Gallatin County.
- * 6. Measurement of Water.
- * 7 Small Grains and Potatoes.
- * 8 Second Annual Report—Crop Statistics of Gallatin County
—Parastic Ictero—Haematuria of Sheep.
- * 9. Potatoes.
- * 10. Small Grains, Wheat, Oats, Barley.
- * 11. Devices for Obtaining a Constant Flow in Laterals with
Variable Heads in the Main Canals or Reservoirs.
12. Third Annual Report, Spaying of Mares.
13. Drinking Water.

14. Montana Swine Feeding.
15. Larkspur Poisoning of Sheep.
16. Fourth Annual Report.
17. An Army Cut Worm—The Grain Aphis.
18. The Alkali Soils of Montana.
19. The Sugar Beet in Montana.
20. Fifth Annual Report.
- * 21. Sheep Feeding.
22. Thirteen Botanical Subjects.
- * 23. Injurious Fruit Insects; Insecticides; Insecticide Apparatus.
- * 24. Sixth Annual Report.
- * 25. Paris Green, and London Purple.
- * 26. Poultry raising.
- * 27. Live Stock Feeding Tests, Beef Cattle, Lambs and Swine.
28. Seventh Annual Report.
- * 29. Quantity of Water Used in Irrigation.
30. Weeds of Montana.
- * 31. Report of Grazing and Feeding Tests, Beef Cattle and Lambs.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
34. Farmers' Weirs.
35. Report of Feeding Tests.
36. Forage Conditions in Central Montana.
37. Pork Production in Montana.
38. Food Adulterations.
39. Sheep Feeding in Montana.
40. Root Crops in Montana.
41. Sugar Beets, (1902).
42. The Codling Moth.
- Ninth Annual Report.
43. The Duty of Water.
44. Apple Growing in Montana.
45. The Loco, and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
49. Contageous Abortion in Montana.

50. Poultry Management and Poultry Diseases.
51. First Annual Report of the State Entomologist.
Tenth Annual Report.
52. Sugar Beets.
53. Creameries and Cheese factories.
54. The Alkali Soils of Montana.
55. Second Annual Report of the State Entomologist.
Eleventh Annual Report.

*Out of Print.

DONATIONS & LOANS.

- John Forsythe, Bigtimber. 3 Sheep for loco experiments
- Van Cleve & Scarlett, Melville. Loaned fence posts, tools and camp outfit and donated use of horse and buggy and board and lodging for one man three months to Chemical Department.
- Bureau of Plant Industry, U. S. Department of Agriculture. 50 lbs. Kleinwanzlebener sugar beet seed.
- Cyphers Incubator Co., 1, No. 2 incubator.
- Peter Koch, Bozeman. About 100 specimens flora from California.
- Miss Millie M. Smith, Forsyth. About 75 specimens flora.
- Mrs. H. F. Henshall, Bozeman. 50 specimens flora.
- Mrs. E. W. Scheuber, Livingston. Specimens flora.
- University of Nevada, 150 species for exchange. . .
- Royal Botanic Garden, Sibpur, India. About 200 species for exchange.
- W. Atlee Burpee & Co., Philadelphia. Flower and garden seeds.
- Oscar H. Will. Bismark, N. D. Sweet corn seed.
- Prof. B. D. Halstead, New Brunswick, N. J. Sweet corn seed.
- Northrup King & Co., Minneapolis, Minn. Sweet corn seed.
- C. C. Willis, Plains, Mont. Sweet corn seed.
- J. C. Teas & Son, Carthage Wis.. 40 plants of hardy flowering trees & shrubs.
- M. Dode, Paris, France. Ulmus Montana seed.
- W. B. Otwell, Carlinville, Ill. 1 package tree paint.
- W. Warnock, Independence, Mo. 1 gallon tree paint.
- Wm. Robinson, Bowling Green Mo. 1 package tree paint.

EXCHANGE LIST.

Agricultural Advertising, Chicago, Illinois.
American Fancier, Johnstown, New York.
American Hay, Flour and Feed Journal, Milwaukee, Wisconsin.
American Poultry Advocate, Syracuse, New York.
Avant Courier, Bozeman, Montana.
Beet Sugar Gazette, Chicago, Illinois.
Bigtimber Pioneer, Bigtimber, Montana.
Billings Times, Billings, Montana.
Bozeman Chronicle, Bozeman, Montana.
Business Farmer, Peoria, Illinois.
Butchers' Advocate, New York, New York.
Butte Inter Mountain, Butte, Montana.
Chicago Daily Drivers' Journal, Chicago, Illinois.
Chicago Livestock World, Chicago, Illinois.
Chicago Markets, Chicago, Illinois.
Chinook Opinion, Chinook, Montana.
Coleman's Rural World, St. Louis, Missouri.
Country Gentleman, Albany, New York.
Daily Independent, Helena, Montana.
Dairy and Produce Review, San Francisco, California.
Desert Farmer, Provo, Utah.
Dillon Examiner, Dillon, Montana.
Dillon Tribune, Dillon, Montana.
Farmer's Advocate, Winnipeg, Manitoba.
Farmer & Breeder, Sioux City, Iowa.
Farmer's Guide, Huntington, Indiana.
Farmer's Review, Chicago, Illinois.
Farmer's Tribune, Sioux City, Iowa.
Farmer, St. Paul, Minnesota.
Farm Home, Springfield, Illinois.
Farm News, Springfield, Ohio.

Farm, Stock and Home, Minneapolis, Minnesota.
Farm Poultry, Des Moines, Iowa.
Feather, Washington, D. C.
Furrow,
Gallatin County Republican, Bozeman, Montana.
Gallatin Farmer & Stockman, Belgrade, Montana.
Gem State Rural, Caldwell, Idaho.
Gleanings in Bee Culture, Medina, Ohio.
Glendive Independent, Glendive, Montana.
Great Falls Weekly, Great Falls, Montana.
Home and Farm, Louisville, Ky.
Homestead, Des Moines, Iowa.
Independent, Miles City, Montana.
Irrigation Age, Chicago, Illinois.
Jersey Bulletin, Indianapolis, Indiana.
Kansas Farmer, Topeka, Kansas.
Kimball's Dairy Farmer, Waterloo, Iowa.
Livestock & Dairy Journal, Fresno, California.
Livingston Post, Livingston, Montana.
Madison County Monitor, Twin Bridges, Montana.
Madisonian, Virginia City, Montana.
Metropolitan Rural Home, New York, New York.
Milwaukee Weekly Journal, Milwaukee, Wisconsin.
Montana Stockman & Farmer, Helena, Montana.
National Farmer & Stockgrower, St. Louis, Missouri.
National Farmer, Winona, Minnesota.
Nebraska Farmer, Omaha, Nebraska.
New York Tribune Farmer, New York, New York.
Northwest Tribune, Stevensville, Montana.
Orange Judd Farmer, Chicago, Illinois.
Oregon Agriculturist, Portland, Oregon.
Pacific Fruit World, Los Angeles, California.
Pacific Poultryman, Tacoma, Washington.
Park, Cemetery and Landscape Gardening, Chicago, Illinois
Plainsman, Plains, Montana.
Poultry Standard, Stamford, Connecticut.
Prairie Farmer, Chicago, Illinois.
Rocky Mountain Husbandman, Great Falls, Montana.
Republic, St. Louis, Missouri.

Rural New Yorker, New York, New York.

Rural Spirit, Portland, Oregon.

Semi-weekly Missoulian, Missoula, Montana.

Southwestern Farmer & Breeder, North Fort Worth, Texas.

Stockgrowers' Journal, Miles City, Montana.

Tribune Review, Butte, Montana.

Wallace's Farmer, Des Moines, Iowa.

Weekly Chronicle, San Francisco, California.

Western News, Libby, Montana.

World, Vancouver, British Columbia.

Yellowstone News, Mondak, Montana.

THE AGRICULTURAL DEPARTMENT.

F. B. LINFIELD, *Agriculturist.*

The report of the Agricultural Department is divided into four sub-heads, viz; Animal Industry, Dairying, Agronomy, and Poultry as each of these divisions have been in charge of different men. Previous to this year the work of the Agricultural Department was under the charge of one man. At the beginning of the year the dairy work was transferred to Mr. W. J. Elliott as Assistant in Dairying with immediate charge of the dairy work. In the spring Mr. A. Atkinson was engaged to take charge of the field crop work as Assistant Agronomist. Later in the season Mr. James Dryden was engaged to take charge of the poultry and as assistant in the Director's office. As each man had charge of a separate division of the work each will make a report for that division.

THE NEW FARM BUILDINGS.

The State Legislature of 1903 appropriated funds for two farm buildings for the agricultural work of the College and Station. Three thousand dollars was made available during the summer of 1903 and was used in the construction of a seed barn for the storage of our farm and experimental grains and seeds. Thirteen thousand dollars became available in the spring of 1904 and was used in the construction of a cattle barn. A brief description of these buildings with plans and illustrations is given in this report. Accompanying this also is a description of the new dairy building finished two years ago.

It is well, perhaps, to bear in mind that these buildings are more than is ordinarily understood by such buildings on the farm. In addition to the use to be made of them as designated by their names, they are also laboratories for our college work with students and for the experimental work. For this reason larger and more roomy buildings are needed than would be required by the average

farmer. There must be ample room to get around freely and so passage ways and storage room must be ample.

The buildings are substantially built and neatly finished. Our claim is that these laboratories for our agricultural work should be as well constructed and should look as well as the laboratories for any other department.

THE CATTLE BARN.

The cattle barn is the largest of the three structures. It consists of a main building facing the north 84 feet by 40 feet with two wings running to the south each 72 feet by 35 feet. Between these two wings there is a room 40 feet by 40 feet.

The main barn is two stories high with a basement 25 feet by 40 feet under the middle of the barn. This basement is used for the storage of roots. The first floor of the barn is used for box stalls, grain storage, and feed rooms. The second story is used for a hay loft. The gambrel roof and the truss supports give very large storage capacity in this loft, which is 40 x 84 feet and 32 feet to the track with not a beam across. This loft will hold 150 to 165 tons of hay.

The east wing of the barn is used for the milk cows and breeding stock. There is room for 38 cows. The stable has a cement floor and cement wainscotting four feet high all around the building. The building is double boarded both outside and in and ceiled overhead. The "Drown" iron stalls are used in this wing. The loft is floored and used for storing the bedding.

The west wing is also 72 x 35 feet and is finished the same as the east wing but is fitted with iron box stalls for the accommodation of calves, young stock and bulls. This wing will accommodate 40 head of animals of all sizes.

Between the two stable wings is a class room 40 x 40 feet used for student work in handling and judging live stock. In this room are the scales for weighing the cattle.

The ground plan and section of the barn will give a clear idea of the arrangement and construction while the illustrations of the front and rear view show well the architectural features of the building which we owe to the architect, Mr. C. S. Haire.

THE SEED BARN.

The seed barn is 36 by 64 feet and a story and a half high. It

too has a gambrel roof which adds materially to the storage capacity of the second story.

There is a driveway 14 feet wide across this building. On the first story one side is used for the storage of grain from the small experiment plots, while on the other side is stored the grain from the larger plots. On the second story one side is used for the storage of sample sheaves of grain, etc., and the other side for the storage of the field crops.

The illustration shows the north front of this building.

THE DAIRY BUILDING.

The dairy building is a story and a half structure facing to the north 40 feet by 28 feet with a one story wing 20 feet by 40 feet. In one corner is a small basement cellar used for the curing of cheese. The first floor is used for butter and cheese making rooms, which takes one side of the building 16 by 40 feet. Along the other side are four small rooms 10 x 11 feet, one for a milk cooling room, one for a pasteurizing room, one a storage room, and one for an office. The wing on the building consists of three rooms, 1st an engine and boiler room, 2nd a fuel room and next an ice house with accommodations for 50 tons of ice.

The second story of the dairy has two rooms, one used as a class room and the other as a testing laboratory.

The equipment of the building consists of 4 separators, 1 milk, and 1 cream vat. Two combined churns and buttermakers, 2 cheese vats and 2 cheese presses and four Babcock testers, besides the numerous other smaller articles needed in the dairy work. The demands for this work have been such that already the building is too small for our needs; and if the demand keeps up the capacity of the building will have to be enlarged. The illustration shows the north front of the building.

ANIMAL INDUSTRY DIVISION.

F. B. LINFIELD.

The Animal Industry Department has continued the feeding experiments during the winter season with a car load each of sheep

and steers. Feeding tests have also been undertaken with hogs, and a study of the records and feeding of the dairy herd has been commenced. No definite experiments with the cows were undertaken as, early in the year, the herd was too small for such work; and of the cattle purchased later in the season we had no records upon which to base a correct division of the herd for a test.

The results of the feeding experiments with steers, sheep, and hogs carried on for the past season will be reported, with those of the coming winter, during the next year.

DAIRY DIVISION.

W. J. ELLIOTT, *Assistant Dairyman.*

Never before has the prospect for creamery building been so promising in Montana as at the present time. Last season some eight creameries were organized and erected. Some of these were built by creamery promoters, who, if our information was correct, charged from \$1,000.00 to \$1,500.00 too much for the plants. Neither the buildings nor the equipment would warrant the exorbitant prices that were charged. This led to the publication of a bulletin by the department on the organization, building, equipment, and management of creameries and cheese factories. This bulletin gave the exact list of all the machinery and equipment that was necessary for such a building. Some 5,000 copies of this bulletin were published. These were particularly for distribution in Montana and for the Experiment Stations of the United States, but numerous copies were asked for by individuals in other states.

We have definite knowledge that the bulletin has been of material value, because in a number of instances contracts, that were already practically closed by creamery promoters, have been cancelled and the creamery association has adopted the plans outlined in the Station bulletin. This was particularly so at Chinook where they later adopted our plans and have now one of the best equipped creameries in the state. The plant was built for \$1,000.00 less than the promoters figures and contains about \$500.00 more in larger size and extra machinery. The supervision of the building of this

creamery, with its ice house, was carried on by correspondence from the Station.

During the year numerous articles were published in nearly every newspaper in the state, advising the farmers to look carefully into any plans that might be submitted to them and telling just what an up-to-date creamery could be built for.

During the year special calls for assistance have come into the Dairy Division from Townsend, Clyde Park, Dillon, Miles City and Crow Creek. These calls were all relative to the starting or organization of creameries.

The advantage of organizing creameries wherever the number of cows warranted it has also been discussed at many of the Farmers' Institutes, and we feel that quite a stimulus has been given along these lines, and that more than ever are the people of this state awakening to the financial opportunities offered by the home market for butter and cheese, and to the profits to be made by a system of dairy farming.

THE DAIRY HERD RECORD.

To find out exactly what a herd of ordinary dairy cows in Montana would produce, 25 cows were purchased from the farmers of Gallatin Valley and are now kept on the Station farm. A complete daily record of the milk produced by each animal is kept, and also a weekly record of the tests of their milk. A record of the food consumed by each animal has also been kept. Thus we know exactly what it takes to keep each cow during the year, and what they are returning in butter and cheese. Instead of selling the hay and grain upon the market we sell them to the cow, charging her with the hay at \$5.00 per ton, and with crushed oats and barley at \$1.00 per hundred lbs. Our idea is to find out definitely whether it pays to feed the hay and grain to the cow. This experiment, though it has been under way for only one year and that with but a few of the cows (as most of the cows were purchased late in the fall and for these we have not the complete year's record,) has brought out some facts very clearly. The first one is that from an average herd of Montana milch cows we have realized \$2.00 for every \$1.00 worth of feed we have given to the animals. In other words by feeding our grain and hay to an ordinary herd of Montana grade milch cows, we have realized \$10.00 per ton for our hay and

\$2.00 per hundred pounds for the grain fed, and this without counting the calf that the cow has reared, nor the skim milk, nor the manurial value which has been returned to the farm. The calf, the skim milk, and the manure will practically pay for the labor and attention required to look after the cow.

Another point that this experiment illustrated is that there is a vast difference in cows as milkers, and consequently as money makers. Some pay a handsome profit on their feed and some do not pay for their keep. We submit a table of a few of the animals to show this fact.

TABLE SHOWING THE YEARLY PRODUCE RECORD OF
SIX OF THE STATION DAIRY COWS.

Name of cow.	Date fresh.	Date dry.	No. Days milking	Lbs. milk per milking period.	Average test.	Lbs. butter fat.	Lbs. butter
Rosie....	Nov. 2, '04	May 19, '05	199	1997.	3.9	69.	80.0
Daisy....	Nov. 1, '04	Aug. 25, '05	298	3911.2	4.0	156.8	183.0
May.....	Nov. 1, '04	Aug. 6, '05	340	6113.2	3.7	227.2	265.0
Mollie...	Nov. 1, '04	Aug. 31, '05	305	8454.6	3.8	323.9	377.8
Glenn.....	Nov. 4, '04	July 13, '05	255	3695.8	4.0	149.3	174.1
Jennie...	Nov. 3, '04	July 13, '05	255	3715.7	4.2	157.4	183.6

Name of cow.	Value of butter at 25c. per lb.	Cost of hay per cow.	Cost of grain per cow.	Pa ture for cow at \$1.00 per month.	Total cost of feed for cow per year.	Net gain or loss per cow..	
Jennie.....	\$20.00	\$14.20	\$ 8.40	\$.	\$22.60	\$ 2.60	Loss in 7 months.
Rosie.....	45.75	14.20	8.40	5.00	27.60	18.15	Gain.
Daisy.....	66.25	14.20	8.40	5.00	31.80	34.45	"
May.....	94.45	15.25	14.70	5.00	34.95	57.50	"
Mollie.....	43.52	14.20	8.40	5.00	27.60	15.92	"
Gip.....	43.90	14.20	8.40	5.00	27.60	18.75	"

From this table it will be seen that cows differ greatly. The cow named Rosie was bought with a herd of 10 others from one man. She was kept for only seven months and demonstrated very clearly that not alone was she not paying for her keep, but she was eating up part of the profit from the rest of the herd. We insert her record for the seven months to show how a cow, which otherwise looked as though she might be a fair milker, would deceive a person who did not keep a strict record of her performance. It will also be seen that several of the cows have made a splendid net profit over the cost of their feed. There is an excellent field in Montana to improve the dairy herds simply by weeding out those that are not paying. This can very easily be done with a hand Babcock tester which may be bought for \$5.00, and a pair of small scales.

Another interesting fact shown by this test is the great difference between the per-cent of fat in the morning's and evening's milk. The morning's milk is generally the richer, sometimes by as much as 1 per cent butter fat. Another thing is the difference in the percent of fat from one day to the other from the same cow, kept as nearly as possible under the same conditions. This varia-

tion is largely a peculiarity of the cow herself, and not something under the control of the manager.

We have not been able to conduct any experiments in the Station Creamery owing to the lack of proper facilities and room, but during the coming year we plan to conduct experiments to study the influence of food upon the flavor of butter and cheese and on the churning temperature of cream.

Besides the above, correspondence of the year, from all parts of the state, has been large. Some 500 letters have been received and answered. This correspondence was principally along the dairy lines of agricultural work. A large number of inquiries have been about hand separators. Some have written asking about the value of skim milk for feed, and others regarding cures for scours in calves which seem to be very prevalent at times and is not confined to any one particular district, but occurs in several different counties. The large majority of inquiries, however, were about the building and equipping of creameries and dairies and regarding the number of cows needed to warrant the establishment of such plants.

AGRONOMY DIVISION.

ALFRED ATKINSON, *Agronomist.*

VARIETY TESTS OF GRAIN.

Several lines of investigation are being followed by this division of the Experiment Station work. Of these, the two most important are; the testing of varieties of grain, grass, clover, roots, and potatoes; and experiments to determine the duty of water in crop growth, which are being carried on in co-operation with the Irrigation Department. It is the plan, at this time, to report the results of variety tests in wheat, oats and barley for the past five years.

Variety tests of grain have been conducted at this Station for the past ten years, and though in many instances the data accumulated is too scant to point to definite conclusions, yet full records of the varieties tested during the years, 1900, 1901, 1902, 1903 and 1904 are at hand.

In addition to the 23 varieties of wheat, 16 varieties of barley and 14 varieties of oats included in this report, 105 varieties of wheat.

28 varieties of barley, 84 varieties of oats, as well as varieties of peas clover, grass, roots and potatoes have been grown since 1894.

The results of many of the above mentioned tests appear in previously published reports of the Experiment Station. In the case of a few very inferior varieties the results have never been published.

The tests are conducted on plots one sixtieth of an acre in size Land that is as near uniform as it is possible to get it is chosen. The same preparation and care throughout the growing season is given to each plot so that any superiority or inferiority indicated by the returns is wholly due to the variety difference.

While the yields in some cases are higher than those obtained in regular farm practice, yet it will be remembered that these are comparative, and are of as great value as though the tests were conducted on larger areas.

VARIETY TESTS OF SPRING WHEAT.

Variety Tests of Spring Wheat. Name	Average Results of the years, 1900, 01, 02, 03, and 04.			Nature of Head.....	REMARKS.
	Bu. per acre.....	Weight per bu...	Days to Mature.		
1. Kubanka.....	59.9	61.9	125	Bearded	Macaroni, hard.
2. Glyndon 692.....	59.0	60.1	123	Bald	Red, hard, good milling.
3. Glyndon 650.....	58.7	59.2	124	Bald	Red, hard, good milling.
4. Glyndon 715.....	56.8	60.9	125	Bald	Red, hard, good milling.
5. Russian 2955.....	56.3	61.1	121	Bearded	Red, hard, good milling.
6. Bart Tremenia.....	54.0	61.9	120	Bearded	Red, medium hard.
7. Glyndon 678.....	54.0	60.0	123	Bald	Red, medium hard milling.
8. Glyndon 768.....	53.1	60.2	127	Bald	Red, medium hard milling.
9. Pringles Champion..	52.9	60.4	120	Bearded	Red, hard, good milling.
10. Glyndon 675.....	52.7	60.1	125	Bald	Red, medium hard milling.
11. Glyndon 774.....	52.7	59.9	125	Bald	Red, medium hard milling.
12. Wild Goose.....	52.2	62.4	126	Bearded	Macaroni, hard.
13. Boulton's Blue Stem..	51.8	58.2	127	Bald	Red, medium poor milling.
14. Bedford's Hungarian.	51.7	59.9	123	Bald	Red, medium hard milling.
15. Glyndon 135.....	51.5	59.2	125	Bald	Red, medium hard milling.
16. Glyndon 673.....	51.0	60.1	126	Bald	Red, medium hard milling.
17. Wellman Fife.....	50.8	59.1	124	Bald	Red, soft.
18. McKissock's Fife....	50.4	60.4	126	Bald	Red, medium hard milling.
19. Red Fife.....	50.0	61.3	127	Bald	Red, extra hard milling.
20. Glyndon 661.....	48.3	58.3	123	Bald	Red, hard, good milling.
21. Velvet Chaff.....	45.9	58.9	126	Bald	Red, soft.
22. Golden Drop.....	45.1	49.1	122	Bald	Red, medium hard milling.
23. Blount's Hybrid.....	38.4	60.6	125	Bearded	Red, medium hard milling.

In reviewing the foregoing table it will be noticed that the Kubanka, one of the durum or Macaroni varieties, gave the highest yield. In the last few years the Department of Agriculture, Washington, D. C. has imported a large number of varieties of this wheat from Europe. As a result of their environment, in that country, they are especially valuable under conditions of scant precipitation, but as these tests were conducted under a system of irrigation it is evident that some of them give good returns even when there is abundant moisture present.

The grain of nearly all the macaroni varieties is larger than the ordinary American grown spring wheat, and is very hard. They are called macaroni wheats because a great deal is used by Italian dealers in the manufacture of macaroni. It is the intention to sow a number of acres of the Kubanka on the Station farm this coming season.

Following the Kubanka, the Glyndons 692, 650 and 715 come second, third and fourth in point of yield. These varieties were first grown at the Minnesota Experiment Station, and have proven themselves superior as milling varieties.

The determinations as to the value of the different varieties for milling purposes were made by Prof. R. S. Shaw, for a number of years Agriculturist at this Station.

VARIETY TESTS OF BARLEY.

Variety Barley Tests. Name.	Average Results of the Years, 1900, 1901, 1902, 1903, 1904.			Nature of Head	REMARKS.
	Bu. per Acre.....	Weight per bu...	Days to Mature..		
1. New Zealand.....	82.1	53.2	109	2 rowed.	
*2. No. 5590.....	77.7	60.5	107	2 "	
3. Mandscheuri.....	75.6	52.9	107	6 "	
4. Calif. Prolific.....	74.6	52.7	110	2 "	
5. Italian.....	73.8	52.0	107	2 "	
6. Manhattan.....	72.5	52.6	108	2 "	
7. Improved Cheyenne...	72.0	53.1	109	2 "	
8. Chevalier.....	69.8	53.2	111	2 "	
9. Guy Male.....	69.7	64.6	104	6 "	Hulless.
10. Champion.....	68.6	53.2	105	2 "	
11. Del Norte.....	68.5	63.5	107	6 "	Hulless and beardless.
12. Golden Thorp.....	69.7	52.5	110	2 "	
13. Kinna Kulla.....	57.9	51.9	109	2 "	
14. Nepbant.....	53.5	60.9	104	2 "	
15. Hungarian.....	47.6	62.2	107	6 "	Hulless and beardless.
16. Berkeley.....	46.0	51.4	107	2 "	Beardless.

*Four years results only.

The New Zealand barley has given uniformly good results throughout the years grown. As a result of brewing tests conducted by Prof. Shaw, and reported in the Experiment Station Report for 1902, it is shown that this variety is excellent as a brewing barley. We hope to have this seed for distribution after next season.

The No. 5590 which gives the second largest yield was received from the Department of Agriculture, Washington, D. C., and sown for the first time in 1901. It is a variety that promises well.

VARIETY TESTS OF OATS.

Variety Oat Tests. Name.	Average results of the Years. 1900, 1901, 1902, 1903, 1904.		
	Bushels per acre	Weight per bushel. pounds	Days re- quired to mature
1. Progress.....	123 5	41.6	118
2. Wide Awake.....	121.6	41.9	117
3. Improved American.....	120.3	39.6	117
4. Mogheda.....	117.2	40.7	120
5. White Swede.....	113.8	39.4	117
6. American White.....	113.6	42.4	122
7. Bland's White.....	113.1	40.6	122
8. White Danish.....	111.9	41.1	118
9. American Beauty.....	110.5	40.6	118
10. Archangle.....	110.4	41.5	120
11. Scotch.....	110.1	41.5	120
12. Great Northern.....	109.4	40.5	116
13. Badger Queen.....	106.4	44.5	117
14. Victoria.....	101.0	42.8	110

In looking over the varieties of oats reported in the foregoing table, it will be noticed that some of the varieties commonly known throughout the State are not included amongst those reported. Of these, possibly the Swedish Select, which gave the highest yield of all the varieties grown for the years 1899, 1900, and 1901, is the one most popularly known. Unfortunately this variety was not included in the plot tests of 1902, and therefore, cannot be included in foregoing list. The Swedish Select has been grown in large quantities at the Experiment Station for a number of years, and large quantities have been distributed. It has proven itself one of the very best varieties for this state. In the plot tests of 1904, the Swedish Select yielded 133.4 bushels per acre.

The Amerisan Banner is another commonly known variety not included in this year's report.

THE FIELD CROPS.

Inasmuch as the crop growing on the Experiment Station farm

is under the supervision of this department, a report of the season's crop is herewith presented:

The Station farm consists of 160 acres, but is not all available for the production of farm crops. Some land is occupied by build-ign sites and feed yards. A portion is used by the Horticultural department. Upwards of ten acres consists of seepy land too wet to cultivate, while a few acres comprise a rocky draw. The area of this so-called waste land is being reduced each year as fast as the means to reclaim it become available.

During the summer of 1904, 116.53 acres of the Station farm were used in the production of farm crops. This includes 21.57 devoted to the plot test work from which no immediate monetary returns accrue. On the remaining 94.96 acres the following crops were grown: Hay 56.96 acres, oats 20 acres, barley 10 acres, spring wheat 5 acres and peas 3 acres.

The total yield of farm crops secured from the 94.96 acres is as follows:

CEREALS.

Oats.. .. .	1423 bushels.
Barley.....	643 bushels
Wheat	304 bushels
Peas	130 bushels
	—
Total	2500 bushels

HAY.

First Cutting, Clover.....	120.18 tons.
Second Cutting, Clover	103.40 tons.

STRAW.

Oat	35.14 tons.
Wheat	12.16 tons.
Barley	19.24 tons.
Pea	7.43 tons.
	—
Total	73.97 tons.

The following shows the average yield per acre of the various crops:

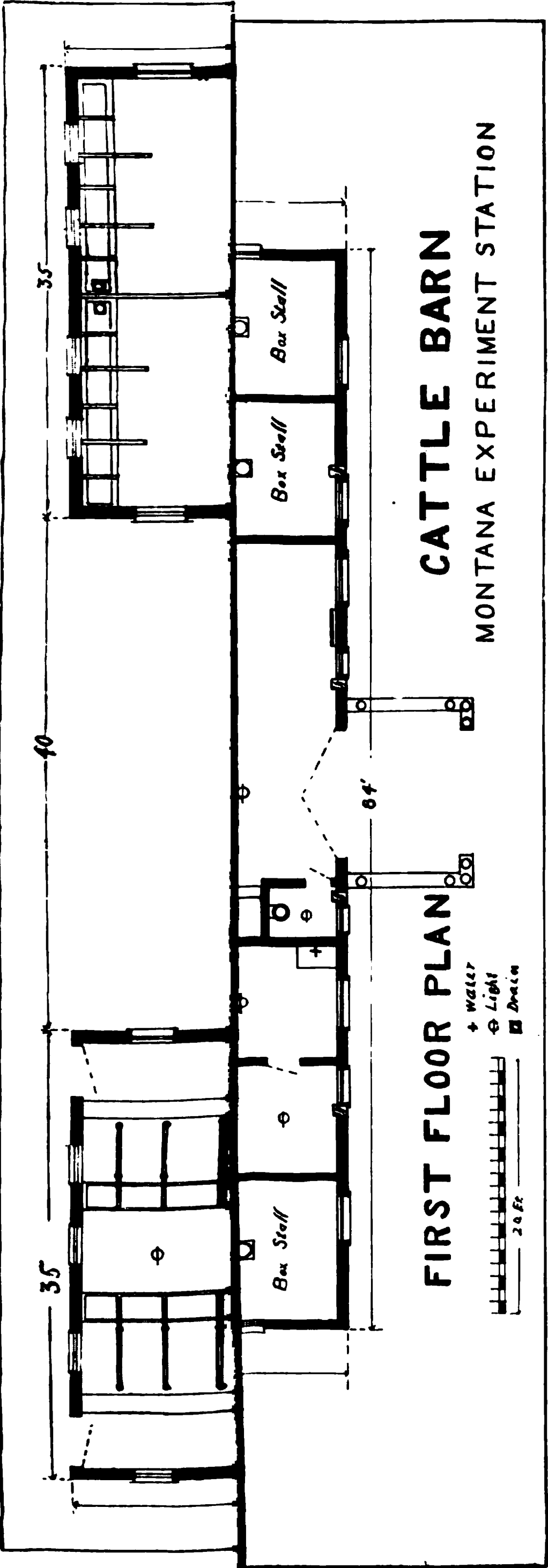
CATTLE BARN.—Montana Agricultural College.

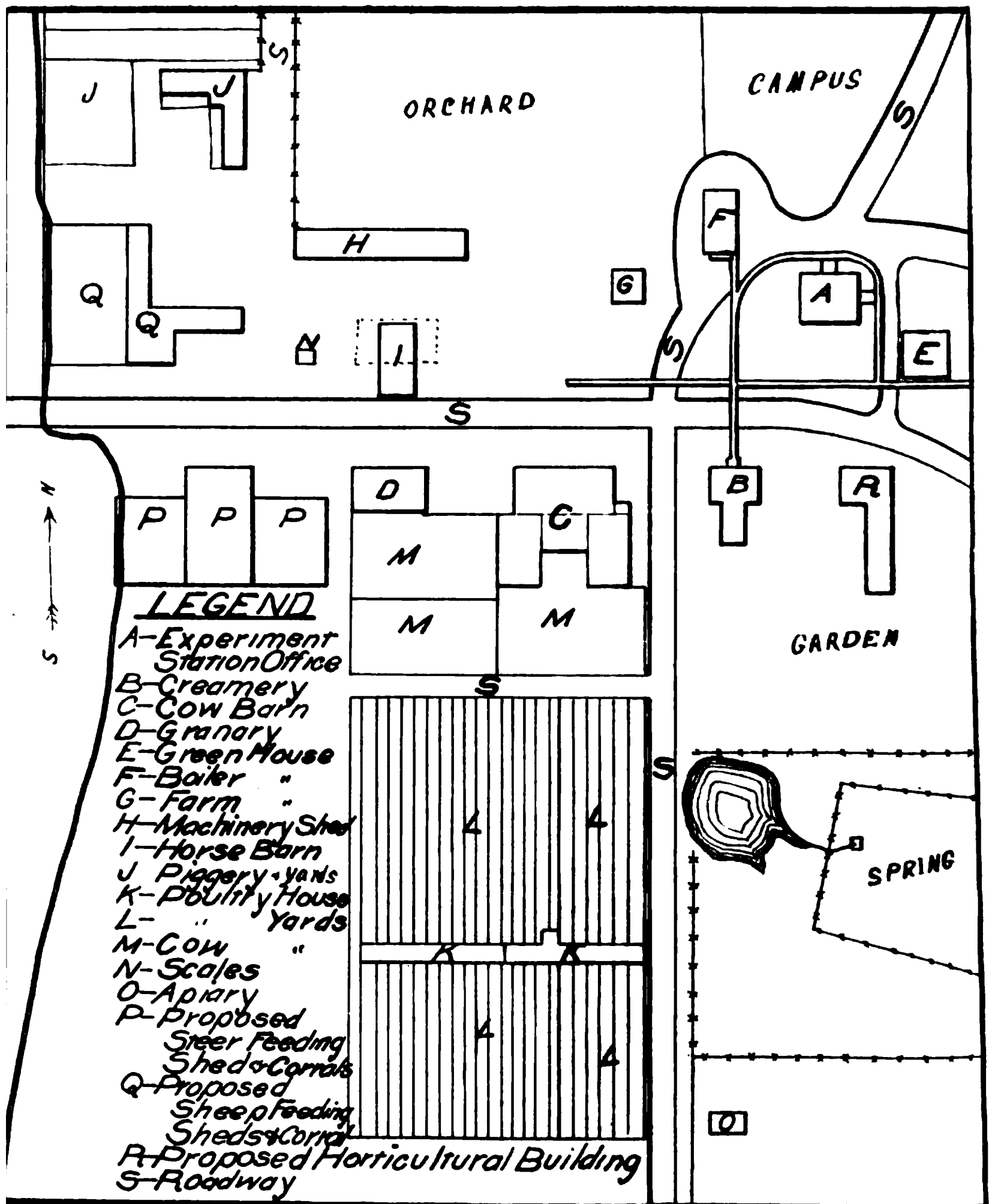
CATTLE BARN, rear view, - Montana Agricultural College.

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Plan of Grounds Showing Location of Farm Building.

CEREALS.

Oats, 20 acre yield 1423 bushels. Average 71.15 bushels.
Barley, 10 acre yield 643 bushels. Average 64.30 bushels.
Wheat, 5 acre yield 304 bushels. Average 60.80 bushels.
Peas, 3 acre yield 130 bushels. Average 43.33 bushels.

HAY.

Clover, 56.96 acres yield 223.58 tons. Average 3.93 tons.

STRAW.

Oat 20 acre yield 35.14 tons. Average 1.76 tons.
Barley 10 acres yield 19.24 tons. Average 1.92 tons.
Wheat 5 acres yield 12.16 tons. Average 2.43 tons.
Pea 3 acres yield 7.43 tons. Average 2.48 tons.

Except in the case of a few varieties of grain sold for seed the crops grown are turned over to the Animal Husbandry Department for the purpose of maintaining the college herds and flocks, as well as for experimental feeding purposes. While the method of disposing of farm crops "on the hoof" is the most profitable, it is our intention to devote more land in future to the production of the very best varieties of farm crops and thus be in a position to furnish these to the growers over the state.

CO-OPERATIVE TESTS.

In 1901 the Experiment Station established a system of co-operative tests with farmers in different parts of the state, for the purpose of determining the value of the leading varieties of grain, grass, roots and potatoes when grown in different localities.

It has been recognized by this, as well as other Experiment Stations, that the varieties which lead in the Experiment Station tests are not always superior when grown in different sections of the same state. The difference in soil and climatic conditions which exist, even within comparatively small areas, are sufficient to cause marked differences in the growth of the various crops.

Perhaps no other state in the union presents as great a variety of crop conditions as does Montana. Its 146,000 square miles of area places it third largest amongst the states. In addition to its great area, its many fertile well watered valleys, separated by dry bench lands, and rugged mountain ranges go to make a variety of crop growing conditions, so that the importance of local tests is very apparent.

While variety differences in farm crops are not the controlling factors in establishing the merit or excellence of any particular kind of grain yet these differences are well worthy of attention. They include the points of superiorities gained by careful selection and growing, or of inferiority that incorporate themselves as a result of carelessness and neglect. In addition, certain varieties have accustomed themselves to certain environmental conditions and do much better under this particular environment than varieties not so acclimated.

An instance of this is shown in the case of the macaroni wheat. This wheat was brought from the dry sections of Europe and as a result of its environment in that country gives much better returns in regions of scant rainfall than other varieties not so acclimated.

The Experiment Station procures varieties from every possible source, and tests them on the Station grounds. Up to the present time 128 varieties of wheat, 70 varieties of oats, 44 varieties of barley, 98 varieties of potatoes as well as varieties of peas, grass, roots, and other crops have been tested. After these varieties have been grown under identical conditions for a number of years those giving the best returns are grown in large amounts and the seed distributed to farmers in different parts of the state. In this way, they are tested under every condition of soil and climate, and the varieties giving the most profitable returns in the different localities are started there, and can be grown in quantities sufficient to seed large areas.

During the season of 1902 experiments were carried on by farmers on fifty farms located in sixteen different counties of the state. The results of this season's work were such as to warrant a continuance of the co-operation. In the spring of 1903 seed was sent to 204 persons representing 21 counties of the state. The replies received as a result of this showed a great difference in the value of the different grains under the various local conditions.

Though no definite arrangements were made for sending out grain in the spring of 1904, upwards of 100 farmers applied to have samples sent. In response to these requests experimental material was sent to 84 of those who applied. Blanks were sent in order that all data might be kept and returned to the Experiment Station. Many of these reports have been returned, and though the data recorded will not warrant a publication of the comparative variety returns, yet these point out many interesting facts.

In addition to the varieties sent out by the Experiment Station most experimenters put in an extra plot, using the variety most commonly grown in the locality. In almost every case the yield from the Station grain was much greater than from the home grown variety. This points out clearly the importance of getting the best varieties, and also shows the value of the careful selection observed in preparing the Station seeds, and the too frequently neglected in regular farm practice.

Many of the crops were grown on the bench lands without added water. Under this condition the early maturing varieties gave much larger returns than the later ones. The moisture from the snows of the preceding winter, and from the spring rains is available for plant growth in the early part of the season only, hence those varieties which make early growth give much larger returns than varieties requiring a long growing season.

Though the returns are not full enough to permit of a report on the comparative value of the varieties when grown in the different counties, yet the distribution of varieties that increase the returns from the farms of the state is of sufficient value to warrant the continuance of the practice.

POULTRY DIVISION.

JAMES DRYDEN, *Poultryman.*

The work of the Poultry Department has been necessarily limited. The efforts have been confined to preliminary work having in view efficient experimental work and greater economy in management. Some repairs have been made to the old building and its ventilation improved. A hot water heater has been put in to heat the laying house during the cold nights of winter and also to furnish heat to the brooder section. A room in the basement has been fitted up for incubators. The house intended for a brooder house has been completed. It is 35 x 14 feet. It is fitted with a hot pipe system and it is divided into seven pens 5 x 8 feet, giving a capacity of about 500 chicks.

Several pens of fowls have been added to the breeding stock. These include White Wyandottes, Single Comb White Leghorns and Rose Comb Brown Leghorns. These fowls are selected with much care as to utility qualities and should make a good foundation of a stock of heavy layers combined with exhibition quality well pronounced.

Most of the pens have been fitted with trap nests by means of which a record is kept of the number of eggs laid by each hen. With more house room and a greater number of fowls more experimental work could be carried on and the work done on a more economical basis.

BOTANICAL DEPARTMENT.

J. W. BLANKINSHIP, *Botanist*.

The greater part of the year was spent by the Botanist in the East on leave-of-absence and the time thus placed at his disposal was spent in the study and determination of the botanical collections of the College and Station at the Gray Herbarium and in the preparation of a series of bulletins pertaining to the botany of Montana. A portion of this time was also employed, with your permission, in the preparation of the botanical exhibit for the state of Montana at the Louisiana Purchase Exposition at St. Louis, where a silver medal was awarded the collection of the forage grasses of the state in the Agricultural exhibit and a gold medal the collection of the flora of the state in the Forestry exhibit, the latter collection going to the State Historical Society at Helena, as the nucleus of a State Herbarium in the Capitol.

After July the principal work of the department was in the study of the plant diseases of the state, in the naming and mounting of the parasitic plant disease material, which has been steadily accumulating for several years in the field work over the state. Also, with the assistance of Miss Lois M. Hartman, a card index has been prepared of all the collections of Fungi in our herbarium, which have been mounted and arranged, so as to be readily consulted in the plant disease work of the Station. Besides the collections made in this state, we now have the following exsiccatae available for use in this work:

Ellis & Everhart's "Fungi Columbiani,," 2100 specimens.

Seymour & Earl's "Economic Fungi," 550 specimens.

David Griffith's "West American Fungi," 400 specimens.

Arthur & Holway's "Uredineæ Exsiccatae et Icones," 164 specimens with several smaller collections.

It is hoped that during the ensuing year the state collections may

be materially extended and the necessary data secured for the preparation of a bulletin on the parasitic plant diseases of the state.

During the year special study has been made of a disease affecting the cottonwoods (*Populus*) of the state, when transplanted for shade purposes. After a number of years the cottonwoods in the yards and along the streets in our cities and towns are apt to become unhealthy, bleed profusely from various wounds and ulcerations and their leaves turn yellow, ending finally in death from exhaustion in from three to five years, though in a few cases they have been known to linger much longer, but no case has been reported where trees once affected have ever recovered and become healthy again. This disease, occurs at Helena, Bozeman, Billings, Deer Lodge and a few other localities in the state and affects the balm of Gilead (*Populus balsamifera*, L.), the narrow-leaved cottonwood (*P. angustifolia*, James) and the river cottonwood (*P. deltoides*, Marsh.), but appears not to attack these species in their wild condition. Studies in Bozeman seem to show that the disease is infectious, spreading slowly from certain infected centers and attacking the trees steadily in all directions from these points, though the spread in some cases is so slow that this has been disputed and further observation is necessary to settle the matter. The yellowing of the foliage is always accompanied by bleeding from one or more points in limb or trunk and sections of the wood usually show a diseased condition of the tissues extending downward from this point, or a definite split in the living wood, extending to the center. It has been thought by some that this condition is due to a lack of moisture in the soil, or to an excess of alkali in the soil water, or to some pathogenic condition of the leaves due to parasitic growth, but there appears to be no relation in situation to disease and there is no fungus specially prevalent on the foliage of such trees. The best name for this disease or condition is "Cottonwood Yellows" and attention is called to it here that data may be secured as to its prevalence in other sections of the state and the region adjacent. The cause of the disease requires further study and experiment for its definite diagnosis and treatment, but it is believed that it may be prevented by the protection of injured parts with a covering of white lead or tar to guard against infection.

With the co-operation of the Horticulturist an attempt has

been made to introduce to our lawns and gardens the more ornamental shrubs and flowers native in the state, the Botanist collecting the roots, bulbs and seeds in connection with his other field-work and the Horticulturist testing their adaptibility for ornamental cultivation. In the early part of the last century the horticultural societies of England had explorers in this region for many years collecting new plants for ornamental cultivation and many then found are still sold at the seed-houses and nurseries; yet we, who live among these beautiful plants of our fields and forests, so fail to appreciate their attractions that little attempt is made to make them bloom in our gardens, even though the expense of collection is small, compared with that of those early explorers. A number of these plants are finding their way slowly into cultivation, like the blue flax (*Linum Lewisii*), the blue columbine (*Aquilegia cærulea*), the yellow columbine (*A. flavescens*), the tall fern (*Asplenium Filix-fœmina*), the prairie lily (*Lilium montanum*) and even the despised sunflower (*Helianthus annuus*) is grown in cultivation in parts of the Flathead valley and in the Koutenai region, where it has not yet appeared as a weed, while our red-willow (*Cornus stolonifera*), the clarkia (*Clarkia pulchella*), coreopsis (*C. tinctoria*), the gaillardia (*G. aristata*) and the yellow currant (*Ribes aureum*) have long been an article of commerce. Yet there are many others that are exceedingly promising for horticultural uses. The trailing juniper (*Juniperus prostrata*), the dog-tooth violet (*Erythronium grandiflorum*), the yellow-bell (*Fritillaria pudica*), the large water-lily (*Nuphar polysepalum*), the various species of *Calochortus*, the moss-phlox (*Phlox Hoodii*), the large flowering phlox (*P. speciosa*), Koch's Sidalcea (*S. campestris*), the wild hollyhock (*Spiræalcea acerifolia*) and the larkspur (*Delphinium Menziesii*) are easily adaptable to cultivation—not to mention a host of others, blooming in spring, summer and autumn, which might be domesticated and are certainly thoroughly hardy, as they are native here..

To secure these plants and test their fitness for cultivation and their value for ornamental purposes is the object of the co-operative work of these two departments and a beginning of this work was made during the past season.

Several new weeds have appeared in the state to which it is desirable to call attention. The perennial sow-thistle (*Sonchus arvensis*, L.) has been introduced at the Station with shrubbery from the East and while for some reason it does not appear to mature fruit here, it spreads from the roots rapidly through the soil and threatens to equal the Canada thistle in pertinacity. This is a plant two or three feet high with yellow flowers resembling the thistle, but smaller, and has spiny leaves and underground rootstocks, which penetrate the soil in every direction.

There has also been introduced with alfalfa, timothy and blue-grass seed the medick (*Medicago lupulina*, L.), the lance-leaved plantain (*Plantago lanceolata*, L.), the toothed medick (*Medicago denticulata*, Willd.) and the hop clover (*Trifolium agrarium*, L.), while a few of our native plants, like *Artemisia dracunculoides*, Pursh, *Coriospermum hysopifolium*, L. and the wild rye *Elymus Canadensis*, L. have been reported as causing trouble in some localities in cultivated fields. While the alfalfa dodder still appears to be reported as occasionally causing damage to this crop, but it has not seemed to persist in the spots affected and so has not here become the pest it has in other countries. It seems to come principally with seed from Utah, where it is more prevalent and dangerous.

The question of the cultivation of Ginseng in Montana has come up a few times recently and it may be well to state that, except in the forest regions west of the Divide, where a native species (*Aralia nudicaulis*, L.) is prevalent—the Flathead and Kootenai regions mainly, it is extremely improbable that our climatic and soil conditions will favor its growth, though it might be well to try it on some of the rich alluvial river bottoms in other places, where irrigation can be secured.

As yet, there have been few demands from this Station for aid against plant diseases affecting fruits and crops and, owing to the relative isolation of the different agricultural communities and the dry climate, few of the worst plant diseases of the East have yet secured definite foothold, the rusts, smuts and potato scabs excepted. There is yet great danger that in many importations of fruit trees, shrubbery and seeds that such diseases will become more prevalent and cause serious loss to the farmer and fruit-grower of the state,

so it is hoped that the appearance of any diseased condition of plants in any locality in the state will be promptly communicated to the Botanist of this Station, that its nature and relative danger may be ascertained, and proper steps be taken to exterminate it, if found dangerous. The co-operation of the State Board of Horticulture is earnestly requested in this work, as their agents situated in every part of the state, may be of the greatest assistance in the recognition of such diseases, from which it is equally important to protect the horticulturist, as from the insect pests, while the Botanist of this Station will be found ever ready to give all the information and aid in his power in the prosecution of such work and our facilities here in herbarium, library and apparatus afford the necessary means for accurate determination.

For the better study of such disease it is the intention of this department to have a card-index made of the literature available for consultation in the state and to procure, as far as funds will permit, the more important economic works dealing with the subject in the United States.

There have been several demands made upon this department during the year for the determination of the relative purity of seeds required for planting, as to the number and kind of weed seeds found, and it is probable that this demand will increase in the future, so that regular work will need to be undertaken for the testing of such seeds for their relative purity and germinating qualities, in which case the facilities for the work of this department will need to be materially extended, the crowded condition of the collections and laboratories being such that the Botanist has no room or table at which he can carry on the experimental work of the Station, all being given up, during the second semester, to student use. It is hoped the state of Montana will provide sufficient facilities for the work of the two biological departments of the College and Station, as the crowded condition of these departments preclude efficient work by professor or student and, by lack of facilities for work, or for the arrangement and storage of material upon which we are studying, or for the care of the apparatus necessary, seriously incommode the progress of the work of the Station. We have been assured that our departments should be the next equipped with a building and proper facilities for the conduct of our work and for eight years have awaited the realization of this promise, each legis-

lature finding it necessary to appropriate the money for other more pressing needs, until now the work in these departments is fairly swamped by the increase of students and collections far beyond the capacity of the temporary quarters provided and these collections many of which are unique and could not be replaced for many thousand dollars, are in constant danger from fire, owing to their unprotected condition and their immediate proximity to the laboratories.

Following out the request of Director Fortier, a series of bulletins has been prepared containing the material accumulated by this department in more technical and popular lines, but it has been thought best that the publication of these be undertaken by the College, the bulletins of the Station to be limited to a matter of immediate economic value, and three of these are now being issued as "Science Studies" of the Montana Agricultural College. A bulletin on "The Native Economic Plants of Montana" has also been prepared for the Station and will soon be ready for the printer.

ENTOMOLOGICAL DEPARTMENT.

R. A. COOLEY' *Entomologist*.

NOTES OF THE YEAR.

In the following paragraphs are recorded scattering observations that have accumulated during the year. With the varying seasons come various insect pests and while during one summer the attention of this office is taken up mainly with some one or more pests, another season brings an abundance of other species, and consequently a shifting of our attention. Some pests attract attention each summer, often varying in abundance and destructiveness, while others drop out of notice for some years, later to reappear and remind us of previous occurrences.

The past season was no exception to the rule and on the whole, was one of great activity in the insect world.

Grasshoppers.—Grasshoppers were much less troublesome this year than during the previous three seasons. Not only were the insects less numerous but there was also sufficient precipitation to produce a good growth of grass on the ranges that had been dry in recent years. We, however, received many letters of inquiry regarding means of securing protection from grass-hopper devastation. As time passed it was found that much less damage was being done than had been feared, yet over extensive areas the insects were very abundant, in some localities more so than the year before. A chief cause of complaint of injuries by these insects was their injuries to the seed heads of alfalfa. A considerable number of ranchers are growing alfalfa for seed and in the region on which the grass-hoppers operated they found that a grasshopper (probably *Melanopus bivittatus* Say) ate off the seed stems causing the heads to drop to the ground.

Realizing early in the season that there was danger of much damage from grasshoppers a circular letter, which discussed and

gave the formula for the preparation of the poisonous "bate" known as "Criddle Mixture", was sent out to all those who the year before had requested a supply of the disease fungus. This letter requested that reports of success or failure with the substance be sent to us in order that we might have information of the practical results for our guidance in future recommendations.

Without further solicitation we received a few replies to these circular letters but desiring more complete returns another circular letter was sent out. This brought in a fairly complete set of replies. We were much disappointed at learning from them that almost uniformly those who had used the mixture had failed to get satisfactory results. However the replies did not state on what dates the mixture was used and we are therefore not assured that it was used early enough to get the best results. It should be borne in mind that this remedy is intended for use only on young grasshoppers.

The Criddle Mixture should be tested with sufficient thoroughness to make sure whether or not it is effective as a remedy in cases of grasshopper outbreaks. A formula for its preparation is given on page 241 of bulletin 51 of this Station. Bulletin 51 is the First Annual Report of the State Entomologist.

A. Cicada.—A cicada which was determined through Dr. Howard of the United States Bureau of Entomology as *Tibicen cruentifera* was locally abundant in a few parts of the Bitter Root Valley. In driving through the upper part of the Bitter Root Valley on June 25 it was noticeable that on approaching bunches of cottonwoods and willows the high pitched and almost deafening sound of great numbers of these insects could be heard. To some extent they scattered from these food trees and were found in apple orchards. A few twigs were injured by the females in depositing their eggs.

The Spotted Blister Beetle.—We received a number of complaints of injuries to the foliage of potatoes and sugar beets and a few other minor plants by the spotted blister-beetle (*Epicauta maculata*). We are informed of very serious damage to potato crops in the vicinity of Big Timber.

Very little has been written regarding this insect, and its habits are not well known but it is quite probable that in its larval stages it feeds on the eggs of grass-hoppers and is thence a beneficial in-

sect. We are, therefore, left in doubt as to what should be recommended in case of damage in the adult stage. It is certain that this insect is very abundant in the eastern part of the state and it may be that our usual freedom from serious injury by grass-hoppers is due to this beetle.

PLANT LICE.

It seems to be a characteristic of our state that plant lice are abundant each season. Probably no other one family of insects is more often the subject of correspondence from this office than this one. We are gradually getting together a collection of these insects and notes are being accumulated and in the course of a few years we hope to be able to present both scientific and practical results.

The one species that is most often inquired about is the apple leaf aphid (*Aphis pomi*). This is very abundant on apple trees throughout the state and though not usually very injurious, is the subject of much interest among the fruit growers, who, as a class are very desirous, not only of preventing injury to their trees but also take a great personal pride in keeping their orchards clean and attractive. This is a commendable spirit not only from an asthetic standpoint but from a business standpoint as well.

Another aphid that is very abundant is the one that attacks cabbages and other plants in the same natural family as the cabbage, known as the cabbage aphid (*Aphis brassicac*). At times this louse is very injurious. There seems to have been no abating of the trouble from this insect during the past year. At least four species, the names of which have not yet been determined are abundant and injurious yearly on the various trees of the genus *Populus* used as shade trees.

One other species which in some parts of the state is very common and noticeable is the elm gall-aphid. It is somewhat surprising that this pest is allowed to continue so abundant when its eradication may be so easily accomplished.

Various other species of less prominence have been common on cultivated vegetation and there are many species on weeds and other wild vegetation.

It is commonly believed that ants are associated with most or all common injurious species but we have no evidence that in Mon-

tana ants have anything to do with the dissemination of the apple aphid, the various species on poplar, the box elder aphid, the elm gall aphid or any of the other well known species. It is true that many of these are visited by certain ants for the purpose of gathering the sweet liquid or "honey dew" but we believe that no service is returned to the plant lice by the ants. Most of our species deposit their eggs on the host plants in fall of the year. In the spring the lice hatch and the winged individuals soon appear and migrate by flights to other trees or plants. It is plain that such species do not require any assistance from ants to enable them to pass the winter in safety and become located on suitable food plants.

It may be that a study of the dark colored species on *Artemisia* which is so constantly to be found in the neighborhood of colonies of our common mound ant would bring out proof of some inter relationship between the two insects but no conclusive facts have yet been adduced. This is a line of work which this department hopes to have opportunity to take up and pursue.

FIELD MICE.

A large part of the activities of this department are made necessary because of the depredations on vegetation by insect life but other animals also occasion some work. The work of field mice was very conspicuous in various parts of the state in the early spring. Just as the snow was leaving the ground their burrows and run-ways were found to be very abundant. In some places they injured lawns by eating off the stems just at the surface of the soil. During the summer, however, these injured spots recovered their former appearance. The most serious injury traceable to these rodents was that done to shade and fruit trees by gnawing the bark off the trunk near the ground. Many trees were killed in Montana last spring by being girdled as indicated.

It will be remembered that snows came early and formed a blanket for the earth which remained until well into the spring. This blanket was a great benefit to the mice not only protecting them from wind and exposure but also hiding them from their everpresent enemies. Orchards in which clean culture is practiced there is very much less danger of injury to the trees from mice. Other things being equal then, it is better to keep the orchard free of weeds, grass,

clover and other vegetation. There is little danger that an orchard in which there is no vegetation except the trees; the soil being kept cultivated will not be frequented by mice. They are vegetable feeders and prefer the tender vegetation to be found in grass lands. They will eat the bark of trees only when driven to it by hunger. Moreover, they will not venture far from cover. Consequently when snow arrives the mice are found only in grass fields, or in fields otherwise covered. When the snow is on the ground they may migrate long distances by crawling under the snow. In this way they sometimes enter orchards that are kept in clean culture but not frequently.

Where ditches with grassy banks run through large orchards it would be well to make sure that no mice are present in the fall or early winter. Grass lands surrounding orchards should also be kept free of the mice. Their presence may be detected by their characteristic burrows and by the dead, brown grass cut off by them. Under conditions where poisons may safely be used it is well to place poisoned grain in places where it will be found by the mice.

Poisoned grain may be prepared in the following manner: Take:
½ounce sulphate strychnine
1 bushel of grain

Dissolve the strychnine in a quart of hot water. Pour this over the grain, mix thoroughly and allow to stand over night. It is thought by some that the poisoned grain is more readily eaten if sweetened and for this purpose a quart of molasses or sorghum is added. After the molasses is added the grain should be again thoroughly stirred. A little corn meal should be added to render the whole mass dry and prevent sticking.

Great care should be exercised in the use of this very poisonous mixture. It should always be kept plainly labeled and out of the way of children and fowls.

A mechanical protection to the trunks of fruit and shade trees is sometimes desirable as in the case of trees on lawns and in back yards: Galvanized wire mosquito netting is probably as good as anything for this purpose. It affords the desired protection to the trees and at the same time does not furnish a harbor for insect pests to hibernate in. It should reach from just to, or just below the surface of the ground to above where snow will reach.

Hawks and owls as a rule are harmless to the interests of man

and some are a great benefit as destroyers of small rodents. Our common "Short Eared Owl" (*Asio accipitrinus*) should always be protected and yet they are being ruthlessly shot through ignorance or pure malice.

The ground color of this bird varies from bright tawny ochraceous to buffy white with conspicuous stripes of dark brown, those of the lower parts growing narrower posteriorly and disappearing on the lower tail coverts. By parting the feathers on the sides of the head very large openings into the ears may be found.

Several individuals of this species may often be seen together.

FIELD WORK.

The work conducted at Missoula on the life history of the eye-spotted bud moth yielded satisfactory results. We feel that in the light of some new facts secured we are able to make some recommendations that will be an aid in controlling this pest. In an experimental way we were able to destroy a very large percentage of the moths by a single well timed spray. We feel that this pest can be easily controlled. The results of this study have been reported in bulletin 55.

Up to the present we have been unable to aid in the control of the strawberry crown girdler, a weevil that in the larval stage has been locally very injurious near Missoula. The problem has been under our attention since the summer of 1900 and during the past season (1904) was given a particular study. A new feature of the study was an attempt to discover the native wild growing food plants.

The practical result was that we now know at least a part of the native food plants and are prepared to make recommendations. The results of this study and the recommendations have been prepared for publications in bulletin 55.

HONEY BEES.

If our line of experiments in the wintering of bees now in progress in the apiary produces reasonably conclusive results we will be in a position in the near future to present in bulletin form a discussion of the very important subject of the best methods of wintering bees in our mountain climate. Definite tests of various meth-

ods are being made and we hope to get results of great practical value.

It is clearly shown that bees kept in good condition will produce a good yield of surplus honey and when we have in an experimental way shown what is the best way of wintering bees it will be best for us to discontinue our apicultural work and sell the bees.

DUTIES AS STATE ENTOMOLOGIST.

As the agricultural development of the state goes on there is a constantly increasing demand for entomological investigations, and this work is greatly facilitated and at the same time safeguarded against becoming local and unpractical by Montana's State Entomologist Law. By its provisions the State Entomologist is required to keep in touch with the needs of all parts of the state and conduct his investigations not only in the office but in the field as well. The fund provided to defray traveling expenses has thus far been found to be sufficient and we believe that the best interests of the state are well served by the present arrangement between the practical and strictly scientific sides of Entomology.

ADDITIONS TO THE COLLECTIONS.

Through an arrangement made with the manager of the Butte Electric Railway Co., Mr. J. R. Wharton, who also has charge of the Company's pleasure resort at the terminus of one of their suburban lines, we were enabled to keep a collector of insects in the field during last summer and substantial additions were made to our collections of insects. Not all this material has yet been worked up but we have determined and arranged the Orthoptera (grasshoppers) and Coleoptera (beetles). These two orders are among the most important from an economic standpoint. Of the Orthoptera we now have nearly 100 determined species from Montana while of the Coleoptera we have about 500 Montana species collected and named. Scattering families and groups from the other orders have been thoroughly worked up and we shall gradually continue the work until the insect fauna of our state is well represented in our cabinets. This will be a work of time and is expensive but is absolutely essential to the proper fulfillment of our duty as an experiment station department.

PUBLICATIONS FOR THE YEAR.

Various newspaper articles have been prepared in response to current needs. While these are sometimes an interruption of other lines of work we feel that they are a profitable use of time for by them we can give information just when and where it is needed. One bulletin, the Second Annual Report of the State Entomologist, has been prepared and submitted. The report will be of about 65 pages with three full page new half tones and one new text figure besides about 30 borrowed text figures.

CHEMICAL DEPARTMENT.

V. K. CHESNUT, *Chemist.*

From September 1, 1903, when my predecessor, Dr. F. W. Traphagen, resigned his duties as chemist of this station until January 20, when these responsibilities devolved upon me, the direction of the chemical work was in the hands of Prof. W. M. Cobleigh under whose management the analytical work in progress on "Foods and Food Adulteration" was completed and the results turned over to Dr. Traphagen who is now preparing a bulletin embodying the results of this work. During the year Dr. Traphagen has completed the manuscript for two bulletins, one treating on the alkali soils of Montana, the other on the prospects of a beet sugar industry in Montana. The former will soon be published by the Station; the latter had already been printed as bulletin 52 of the Station. Both of these bulletins embody the ripe experience, not only of the past year but of the past ten years during which Dr. Traphagen acted as Chemist of the Station.

THE BEET SUGAR INDUSTRY OF MONTANA.

The past year has witnessed a great advance in the prospects for a beet sugar industry in the state. The erection of factories is now being considered at Kalispell and Great Falls, and in the Milk River, and Bitterroot valleys and already the erection of a large factory with a daily capacity of 1000 tons of beets has been assured at Billings. The cost of this plant will be about \$750,000.00 and nearly 400 men will find employment in and about the factory. Surely this marks the beginning of an important epoch in the history of the state, the dawn of manufactory!

COOPERATION WITH FARMERS.

(a) *Sugar Beets*:—Owing to the delay in securing beet seeds from the Department of Agriculture and to the unusual dryness of the growing season the co-operative experiments with beets were

not so satisfactory this year as usual. About 50 pounds of Kleinwanzlebener beet seed was distributed by the Station. This seed was secured by the U. S. Department of Agriculture in the state of Washington and was grown in that state from mother beets of high sugar content and purity. The results with these beet seed are of particular interest on account of the fact that the government is now particularly interested in encouraging the sugar beet seed industry in this country.

The richest lot of beets grown from these seeds was grown by Rosa Kent of Hinsdale in Valley County. The beets contained 22.8 per cent sugar, an amount equaled in this state only by the beets raised at Hinsdale by W. M. Wooldridge in 1902. One other sample from Hinsdale, one from the station farm and two from Billings contained a little over 21 per cent sugar. The greatest estimated yield of sugar per acre from this seed was 5825 pounds, the record of the Station farm.

Complete comparative tests made with three other varieties on the Station farm showed that the Government seed yielded beets superior in every particular save one; the Utah grown seeds yielded beets, the purity test of which was 1.08 per cent. greater. The full comparison is shown in the following table.

SHOWING COMPARATIVE RESULTS WITH SEVERAL VARIETIES OF SUGAR BEETS.

Number.	Date planted.	Date harested.	Date irrigated.	Kind of seed used.	Tons of beets per acre.	Pounds sugar per acre.	Sugar in beet.	Purity Coefficient.
2670	May 21	Oct. 20	July 22	Vilmorin's Imperial	13.27	2348	13.6	78.88
2671	" "	" "	" "	Utah Sugar Beet....	14.18	4141	18.52	89.86
2672	" "	" "	" "	French Red Top....	14.50	2635	11.88	76.36
2673	" "	" "	" "	Kleinwanzlebener...	14.73	4920	18.8	88.78
2674	" 23	" "	" "	Morrison Grown....				
				Kleinwanzlebener...	15.5	5825	21.45	87.6

The average of 22 beets grown in various parts of the state from the government seed showed 16.9 per cent sugar in the beets and 82.73 per cent purity. These percentages, although good averages, would undoubtedly have been considerably higher if more care had been taken in the cultivation of the beets, and if the season had not been abnormally dry. Some complaints were made also in regard to the ravages of the beet beetle (*Epicauta maculata*) which devours the leaves of the plants with great gusto.

(b) *Alfalfa Growing*.—Through the courtesy of Dr. Geo. T. Moore of the Bureau of Plant Industry, Department of Agriculture, cultures of bacteria for inoculating alfalfa seed were sent to farmers in several parts of the state but sufficient time has not yet elapsed for the reports to be turned in. Present indications are that the treated seed produced more vigorous seedlings. Considerable difficulty has been reported from several parts of the state in getting a good stand of alfalfa. This trouble is often due to a lack of nitrogen in the soil. The nitrifying bacteria when present on the plant get this, the most costly of all fertilizers, from the air. These organisms should, therefore, be extensively tried in this state, not only for alfalfa but for all leguminous crops.

COOPERATION WITH STOCKMEN.

The stockmen of the state are now rapidly learning that they cannot depend wholly upon the public range for pasturage and that in order to avoid extensive losses either from poisonous plants, extreme cold, drought, or from parasitic diseases it is necessary for them to reduce materially the number of stock grazed on a given area or to provide hay sufficient to keep them alive especially during periods of inclement weather. The cooperation with the stockmen has been mainly along two of these lines, viz; poisonous plants and parasitic diseases, both of which have an intimate relation to the food supply.

(a) *Poisonous Plant Investigations*.—In this line experiments were made definitely to determine whether or not the veratrine alkaloids, the poisonous principles of Death Camas (*Zygadenus venenosus*) leaves, pass into the milk of animals poisoned by the plant. It was found that they did and that their presence in milk was very easily determined. It is, therefore, certain that a ewe or a cow

suffering slightly from Death Camas poisoning may fatally poison her off-spring through her own milk.

(b) *Investigations on Parasitic Discases of Sheep*:—Through the generous cooperation of sheepmen and of the Bureau of Plant Industry, Department of Agriculture, a great deal of information has been obtained relative to the effect of scanty food and the consequent impairment of vital force upon the ravages of parasitic insects and worms in sheep. This information was obtained during the progress of the investigation of the so-called "Locoweed Disease" of sheep and will be published by the Station as a part of that work. About 80 sheep were divided into several bands and, while suffering from an attack of the Gad Fly, were fed different amounts of food. Concordent results were obtained.

About 30 badly locoed sheep have been obtained and treated with vermifuges in order to kill or cripple the intestinal worms. An attempt is now being made to fatten these sheep for the market.

FOOD INVESTIGATIONS.

There being no state law regulating the sale of foods other than meat and milk, not true to name or label, the principal work done in this line was in co-operation with the State Veterinarian, Dr. M. E. Knowles, who has charge of the Meat and Milk Inspection law. Several samples of sausage and of meat preservatives were submitted by the local inspector, Dr. H. C. Gardiner. These were obtained chiefly from Bozeman butchers. Some of the sausages contained an excessive amount of such objectionable preservatives as sulphite of soda and borax but their use in the sausage was discontinued by the butchers when they were informed of the results of the analysis. Subsequently, an agent of an eastern house trying to place orders among his customers for a further supply of certain spices and preservatives was not only unable to sell his preservatives but had returned to him some of the material which had been sold by him the preceeding year. It was the confessed purpose of this agent to sell the preservatives returned in another town in the state where the inspection was supposed to be less rigid.

One fatal case of poisoning from canned salmon was inquired into. One child died and two others were made very ill by eating the contents of a pound can of the fish very shortly after it had been opened. The symptoms were those usually observed in cases

where partially decayed fish are eaten. Probably in this instance the fish was poisonous before the can was opened. Perhaps it was what is known to some wholesale dealers as a "do-over," that is, a can of salmon which having begun to ferment before leaving the cannery, has been recanned. This process would kill the bacteria causing the fermentation but would leave the poisonous ptomaine unchanged. The practice of selling such goods should not be tolerated! No better evidence could be needed to indicate the necessity of establishing a pure food law in this state.

Miscellaneous.—Miscellaneous samples, of water, soils, grains coal-oil, coal, etc., were submitted for analysis and some co-operative work was done with the Bureau of Chemistry. Two Farmers' Institute trips were made and considerable progress was made in systematizing the office records.

METEOROLOGIST SUMMARY FOR 1903-1904.

EDMUND BURKE, *Meteorologist.*

Highest temperature.	89	August 14, 1904.
Lowest temperature.	-23	Nov. 17, 1903.
Greatest range for the year.	112	
Highest monthly mean.	63.6	August 1904.
Lowest monthly mean.	22.4	February, 1904.
Highest daily mean.	71	July 26, 27, August 14, 15, 1904.
Lowest daily mean.	-11	November 17, 1903.
Mean temperature for the year	41.2	
Greatest total pptn. for 1 month.	2.98 in.	March, 1904.
Least total pptn. for 1 month.	.06 in.	Sept., 1904.
Total rainfall.	16.34 in.	
Total snowfall.	95. in.	
First killing frost.		Sept. 13, 1904.
Last killing frost.		June 10, 1904.
Number of clear days in the year	103.	
Partly cloudy days.	224.	
Cloudy days.	39.	
Days with .01 inch or more pptn.	89.	

SUMMARY BY MONTHS FOR 1903-1904.

Months and years.	Highest temperature..	Lowest temperature.	Mean temperature..	Precipitation.	Snow-fall.	Clear days.	Partly cloudy days.	Cloudy days.	Days with .01 of an inch or more precipitation.....	Direction of prevailing winds
Nov. 1903.....	67	23	27.1	1.77	16.3	6	15	9	9	S. E.
Dec. 1903.....	54	3	25.2	.78	7.8	7	19	5	6	S. E.
Jan. 1904.....	48	4	22.5	.85	8.5	3	21	7	7	S. W.
Feb. 1904.....	49	-12	22.4	2.25	22.5	4	21	4	8	S. E.
Mar. 1904.....	50	-20	25.	2.98	28.1	7	22	2	11	S. E.
Apr. 1904.....	72	16	41.9	1.36	5.6	12	16	2	8	S. E.
May 1904.....	74	28	48.2	2.02	4.4	5	21	5	10	S. W.
June 1904.....	84	32	55.1	1.74	1.8	9	20	1	12	S. W.
July 1904.....	88	36	62.1	1.11		10	21	0	7	S. E.
Aug. 1904.....	89	34	63.6	.86		12	19	0	6	S. E.
Sept. 1904.....	88	27	54.7	.06		15	13	2	1	S. E.
Oct. 1904.....	75	20	46.2	.56		13	16	2	4	S. E.

HORTICULTURAL DEPARTMENT.

R. W. FISHER, *Horticulturist*.

The work in this department has been along much the same lines have been followed in previous years, that is, in testing new varieties of fruits, ornamental trees, flowers, shrubs and garden vegetables.

Considerable time has also been given during the past year to cross pollenating flowers of fruits and certain vegetables with the idea in mind of producing plants better suited to our conditions than any we now have. From the very nature of this work it will be some years hence before we hope to be able to give a report upon it.

PRELIMINARY REPORT UPON ORNAMENTAL TREES AND SHRUBS..

Many kinds of ornamental trees and shrubs are now growing in the experimental nursery and while some of them have not been tested for a period long enough to determine accurately their hardiness yet the notes here given will indicate those kinds that are most likely to grow at this altitude and in places in the state similarly situated. They will also call attention to those varieties that our tests show are probably too tender for general planting. A great many ornamental plants growing in the nursery are not mentioned here because they have not been tested long enough to prove their worth.

American Ash, (*Fraxinus Americana*. Linn.).

In localities where this tree can be grown it will make an excellent tree both for ornamental and economic purposes being one of the best of its kind.

Small trees planted here in the spring of 1903 have had the tops winter killed during the winter and the foliage and tips of the plants are killed in the fall by early frosts.

A few old trees on the Station grounds seem to be perfectly hardy and mature their wood in the fall and come through the winters all right, and it may be that after the young stock has become

entirely acclimated they will be hardy. At present, however, at altitudes similar to the Gallatin valley this tree should not be planted except for experimental purposes, especially when it is not possible to procure the stock from climates very similar to ours.

Green Ash. (*Fraxinus viridis*, Michx.)

This is a much smaller tree than the white ash and grows slower. Both large and small trees grown at this station have been entirely hardy and where trees are grown from seeds procured in locations with similar climatic conditions to ours, this tree will likely prove useful as windbreaks, etc.

European Mountain Ash. (*Sorbus Aucuparia*, Linn.).

This tree has been growing on the Station grounds for nine years and seems to be perfectly hardy. It makes a tree 20 to 40 feet high and is valuable for ornamental purposes.

American Mountain Ash. (*Sorbus Americana*, D. C.).

This tree makes a more shrubby growth than the preceeding and requires considerable pruning to train it into tree form. It is harder than the European Mountain Ash and will therefore stand more exposed and colder situations.

Black Walnut. (*Juglans nigra*, Linn.).

This is not a safe tree to plant in Montana in the colder and higher altitudes. The terminal shoots winter kill badly and the foliage is usually killed on the trees in the fall, before they mature.

Russian Mulberry. (*Morus alba*, var. *Tatarica* Loudon.).

So far the tests with this tree indicate that it is too tender for this climate and should not be planted except for experimental purposes.

Western Catalpa. (*Catalpa speciosa*, Warder).

The terminal shoots kill back each winter to the old wood and the leaves usually are killed before they mature in the fall. Too tender for this climate.

Sugar Maple. (*Acer saccharum*, Marsh).

On young trees the terminal shoots winter kill and unless trees are grown from seeds gathered in high and cold altitudes it will not prove hardy enough for general planting.

Silver Maple. (*Acer saccharinum*, Linn.).

Trees grown from seeds of trees gathered in eastern states or states south of here are invariably tender, only a very few specimens

proving hardy. But when stock is procured from cold climates this tree may prove hardy enough for general planting, and is surely worth all the effort given in testing it as the silver maple is one of the best ornamental and shade trees grown.

Tartarian Maple. (*Acer Tataricum Ginnala*, Hort.).

This is a small shrubby growing tree that seldom reaches a size of over 15 or 25 feet, but on account of its hardiness is valuable as an ornamental shrub or it may be used to advantage as a wind break.

Box Elder. (*Acer Negundo*, Linn.).

This tree is a native to parts of Montana and can be grown under cultivation in most parts of the state. The Box elder is a rapid grower, often attaining a height of 30 or 40 feet; but is usually more spreading. It is valuable as a shelter belt and where other more ornamental trees will not grow is good for shade and ornamental purposes. Seeds gathered from native trees will likely produce hardier trees than trees purchased from eastern nurseries.

American Elm. (*Ulmus Americana*, Linn.).

This is one of the best and most durable trees for shade or ornamental purposes. Trees imported into the state or grown from seeds matured in warmer climates are very likely to prove tender but when propagated from trees grown in cold climates the American Elm will very likely prove hardy enough for general planting. The elm thrives best upon moist, rich soils, and will not stand much drought.

Bur Oak. (*Quercus Macrocarpa*, Mich.).

This tree is native to parts of Montana where it is known as scrub oak. It is a very slow growing tree and does not attain to any great size, but seems to be perfectly hardy at this altitude. It is not valuable for shade or shelter purposes because of its slow growth and small scrubby size.

White Birch. (*Betula alba*, Linn.).

This is one of the hardiest and finest ornamental trees for the higher and colder sections of Montana. Because of its slender growth and small leaves it is not so valuable as a shade tree but affords considerable protection against winds. It thrives best upon moist soil and will not stand much drought.

Carolina poplar. (*Populus deltoides* var. *Carolinensis*, Marsh.)

Below altitudes of 4500 feet this is probably the best shade and ornamental tree growing in the state for general planting. Above 4500 feet it sometimes winter kills, especially when the wood is not perfectly matured the preceeding fall. The Carolina poplar thrives best upon moist soils and will make but a poor growth where water cannot be supplied. Many specimens of this tree died on the Station grounds and in Bozeman last year, caused very likely from the fact that sufficient moisture was not in the ground to carry them through the winter. The tree is also somewhat subject to sunscald and while small should be given some protection against the sun during the winter.

Certinensis poplar. (*Populus laurifolia*, Ledeb).

This tree is not as hardy as the Carolina poplar, nor does it make as good a tree. Where the poplars are to be planted the Carolina should be given preference.

Black Poplar. (*Populus betulafolia*, Pursh).

This tree seems perfectly hardy here and is valuable for shelter belts.

Buffalo Berry. (*Sheperdia argentea*, Nutt.).

This shrub is native to parts of the state and is valuable as a hedge plant and in some cases would make a good shelter belt. The fruit is used for jellies and jams and if plants are set out with the intention of getting fruit it is necessary to get plants bearing both staminate and pistilate flowers. This plant is hardy here.

Purple Beech.. (*Fagus Sylvatica purpurca*, Ait.).

Too tender for this climate.

Japan Quince. (*Cydonia Japanica*, Pers.).

This is a shrub growing 3 to 6 feet high with branches. The flowers range in color from white to scarlet and are very fragrant. This plant is seldom winter killed except when planted in exposed situations.

Purple Fringe, (*Rhus cotinus*, Linn.).

A shrub 6 to 8 feet high with purple flowers which appear in early summer. It has not been winter killed since planted here and may prove to be a hardy and valuable bush.

Deutzia.

Several species of deutzias have been tested and without exception have been tender.

Spiraea. (*Spiraea Reevesiana*. Lind.).

Not hardy.

Van Houtts Spiraea. (*Spiraea Van Houttei*, Zabel.).

This is one of the most beautiful of the spiraeas and is quite hardy here. Very useful and ornamental for the shrubbery and single planting.

Mock Orange. (*Philadelphus, Lemoinei*. Lemoine.)

This large flowering mock orange is about half hardy here, the terminal shoots killing back in very cold weather.

Mock Orange. *Philadelphus, Lemoinei*. (Lemoine.)

A smaller shrub than the foregoing and about the same in respect to hardiness. Both very likely to be found perfectly hardy at lower altitudes and in sheltered locations.

Tamarix Gallica. Linn.**Tamarix Africana.**

Both these plants have been grown here for several years and kill to the ground each winter. The roots seem to be hardy and new shoots spring up each spring and make a growth of 3 to 4 feet during the season.

Scotch Laburnum, (*Laburnum alpinum*. Griseb.)

A very graceful and ornamental shrub for border planting. The tips of the terminal shoots sometimes kill back but usually the plant will make a good growth during the summer.

Snowball. (*Viburnum opulus sterile*. DC.).

This is a very good plant for specimen planting and is very showy in the border. Not absolutely hardy here, but usually survives winter killing and makes a good subsequent growth.

Arrowwood. (*Viburnum dentatum*. Linn.)

This plant is not as ornamental as the preceeding one but probably is a little hardier.

Oregon Grape. (*Berberis aquifolium*. Pursh.).

A small evergreen shrub valuable for planting out in the border. Seems to be hardy here especially when given slight protection.

Lilac. *Syringa*.

The lilacs are among the hardiest ornamental plants we have at this altitude and are very valuable for grouping or for specimen plants upon the lawn.

The Common Lilac. (*Syringa vulgaris*, Linn.).

The common lilac is too well known to need description. It is very hardy and is one of the best shrubs we have to plant for general ornamental purposes.

Syringa villosa. Vahl.

This variety is lower growing than the common lilac. The flowers are pinkish lilac and have a delightful fragrance not quite as strong as the foregoing. Hardy.

Syringa Rothomagensis. Loud.

This lilac attains a height of 10 to 12 feet in good soil. The leaves are smaller than the common lilac and the flowers purplish violet in color are produced in abundance. Hardy.

Persian Lilac. (*Syringa Persica*. Linn.)

This shrub attains a size of from 5 to 10 feet, and produces flowers in large white clusters. Hardy.

Siberian Pea Tree. (*Caragana frutescens*. DC.).

A small shrub very beautiful both in leaf and flower. It produces beautiful yellow pea-like flowers and has been perfectly hardy here for six years.

Siberian Pea Tree. (*Caragana arborescens*, Lam.)

This is a large shrub or small tree sometimes reaching a height of 10 to 15 feet. It is very useful either as a hedge plant or for ornamental purposes. It has not been tested very long here but so far has shown no signs of winter killing.

Yellow flowering currant. (*Ribes aureum*. Pursh.).

Native to parts of Montana and perfectly hardy here. It is a free growing plant often attaining a height of 6 to 10 feet and produces in the spring, yellow, fragrant flowers. A good plant for massing where tender plants will not grow.

Honeysuckle. (*Lonicera Tatarica*, Linn.)

A large growing honeysuckle, producing flowers profusely in early spring. Very hardy and desirable for general planting. The flowers range in color from white to red.

Berberry.

Plants of this genus are very useful for hedges, and are very ornamental when placed singly on the lawn. They also make good plants for the border. Young plants introduced into Montana at this altitude may have the terminal shoots killed for a few years

but they seem to become acclimated after a while and are perfectly hardy. With these as with all other plants it is much better and safer to get stock from northern nurseries, or from plants matured in cold climates.

American barberry. (*Berberis Canadensis*. Mill.)

Rather small growing species from one to three feet high, with blackish purple leaves. Seems to be hardy.

Common barberry. (*Berberis vulgaris*. Linn.).

Plant growing from 4 to 8 feet; racemes pendulous with many yellow colored flowers. This is a very handsome plant in the spring with its golden yellow flowers and bright green leaves.

Purple-leaved Barberry. (*Berberis vulgaris atropurpurea* Rgl.)

This is a plant closely resembling the above except the leaves are a deep purple. Both seem to be hardy after becoming acclimated.

VEGETABLES.

The following varieties of vegetables were grown in the experimental gardens this year. It is intended to publish in bulletin form in the near future what data has been gathered on vegetable growing and this report will show only the general results of the past year

BEANS.

From forty-three varieties of beans tested this year the following seven gave the largest yield of green or snap beans per acre:

Large White Kidney:—Vines rather large for the bush beans, with large green pods, not free from string even when quite young, and for this reason may not be so desirable as some others.

Davis Dwarf White Wax:—Small vines but very productive, producing large pods which are distinctly tough and stringy.

Best of All:—Large vine producing many pods which are tough and stringy.

Golden Eyed Wax:—Large vines very productive. Pods wax colored and quite free from strings; very good for home or market purposes.

Kecney's Rustless Golden Wax:—Large vines very productive throwing out long tendrils. Pods large, light colored, and distinctly free from strings and of fine quality. All things considered this is probably the best variety for string or snap beans tested.

Crystal White Wax:—Vines large and spreading with many

stems. Pods rather small and produced in great profusion. Not free from strings when old.

Wardwell's Kidney Wax:— Vines very large with rather few stems. Pods medium size, wax yellow and produced in great abundance. Distinctly free from strings.

BEETS.

Three varieties of beets were grown, viz.: Crimson Globe, Black Red and Early Model. The first named gave the largest yield per acre, but is not as early as either of the other two.

CABBAGE.

Cabbage is one of the most profitable garden crops grown and often by a careful selection of varieties the yield may be doubled with the same care and management. It is, therefore, very important to give careful attention to the selection of varieties. In the test of this year 12 varieties of cabbage were included. The earliest were Early Spring, Early Base-ball, and Early Jersey Wakefield. The varieties, Succession and Early Summer, while a few days later, are much better for market purposes, producing more solid and larger heads and remaining in marketable condition for a longer period.

The late cabbages are, however, the most profitable but on account of insect enemies, especially the cabbage aphid, the crop has been smaller than usual for the past year. Thorough spraying with kerosene emulsion or tobacco solutions will hold the aphid in check.

This year's test shows that Danish Round Head, Late-~~Ston~~head and Late Flat Dutch are the best varieties to grow for the late crop, thus confirming the tests of previous years.

CORN.

Ten varieties of early sweet corn were tested in the experimental plots during the past season.

Golden Bantam:—A small plant about four and a half feet high with a rather short stalk which develops ears early.

The ears average about six inches long and are of good quality. Produced roasting ears August 25.

White Cob Cory:—Plant 5 ft. high, vigorous, with stout stalk bearing two or more ears which average about six inches in length. Very good in quality. Ears first usable August 22.

No. III. Seed obtained from Mr. C. C. Willis, Plains, Montana, where it has been grown for a number of years. Plant about

four and one-half feet high, hardy and produces ears about six inches long. Quality very good. Ears first usable August 18. This variety resembles very closely the White Cob Cory but seems to be a little hardier and early.

Extra Early Cory:—Very similar to White Cob Cory. Ears first usable August 22.

Earliest Sheffield:—Plant six and one half feet high, strong and vigorous, but did not produce ears fit for use before frosts. Apparently too late for this altitude.

First of All:—Plant 5 feet high; slender stalk, producing usually one ear, about six inches long. Ears first usable August 22.

Early Fordhook:—Plant 5 feet, stalk slender, producing usually one ear to a stalk. Ears about 6½ inches long and of good quality. Ears first usable August 22.

Peep O'Day:—Plant four and one half feet high, stalk rather slender, producing usually one ear to each stalk. Ears six inches long and of good quality. Ears first usable August 18.

Voorhees Red:—Plant very vigorous and thrifty but too late for this altitude. Did not produce usable ears.

Wills Early June:—Plant four feet high; stalk slender, producing usually one ear to a stalk. Ears five and one half inches long and of very good quality. Ears first usable August 18.

ONIONS.

Thirteen varieties of onions were planted in three different plots, as follows:

First:—Seeds were sown in flats in the greenhouse April 30, and transplanted into the open May 21.

Second:—Seeds were sown out of doors May 14.

Third:—Seeds were sown out of doors May 21. The following table gives in detail the results.

Variety.	Average weight in ounce per bulb No. 1.	Average weight in ounce per bulb No. 2.	Average weight in ounce per bulb No. 3.
Yellow Globe Danvers.....	2.789	2.632	2.444
Prize Taker.....	4.752	3.756	2.382
Large Red Globe.....	3.047	2.574	2.066
White Silver Skin.....	3.68	2.133	1.860
Golden Globe.....	4.813	2.666	2.54
Yellow Dutch.....	3.911	2.191	2.248
Extra Early Red.....	4.815	2.534	2.156
Southport Large Yellow Globe.....	3.773	2.666	2.694
Large Red Wethersfield.....	3.133	2.106	2.071
Australian Brown.....	5.309	2.966	2.96
Extra Early Australian Yellow Globe.	4.590	2.306	2.608
Large White Globe.....	3.196	1.129	2.24
New Mammoth Silver King.....	2.686	1.142	.6
Average.....	3.884	2.369	2.221

These results, as in previous tests, show that there is a decided gain made in yield, by transplanting onions from an early seed bed.

The above table also indicates that early sowing of seeds out of doors will give better results than late sowing.

IRRIGATION DEPARTMENT.

J. S. BAKER, *Irrigation Engineer.*

The work of the Irrigation Department for the past year has been conducted for the greater part in co-operation with the U. S. Department of Agriculture and with the State Engineer of Montana.

CO-OPERATION WITH THE IRRIGATION AND DRAINAGE INVESTIGATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE.

By agreement between the Honorable Secretary of Agriculture and the Director of the Experiment Station definite lines of work were carried on in Gallatin, Ravalli and Yellowstone counties. The essential part of the agreement is here given:

That co-operative investigations shall be conducted in the State of Montana, by both parties to this agreement during the fiscal year beginning July 1st, 1904 on the following named branches of irrigation and drainage:

(1) To determine the relation between crop yield and amount of water applied in irrigation, by experiments on plats and also in tanks on the farm of the Montana Experiment Station.

2. A study of dry farm methods in Cascade, Beaverhead and Gallatin counties.

3. Experiments to determine the effect of winter irrigation in Montana.

4. A continuation of the experiments on the duty of water under one or more canals of Yellowstone, Ravalli and Gallatin counties.

5. Drainage investigations on an experimental tract near Billings, Montana.

The data for most of these reports are too extensive and yet not sufficiently complete to be given in this report and will later be published as separate bulletins.

DUTY OF WATER EXPERIMENTS.**IN GALLATIN VALLEY.**

Duty of water experiments were conducted in the Gallatin Valley following what has been done in years previous so that more complete data might be obtained. The canals tested, were the High Line Canal of the West Gallatin Irrigation Company, the Cameron Canal, and the Middle Creek Canal. Registers of gage hight were placed in the rating flumes and records of the flow determined for the entire season.

The twelve tanks used formerly on the Experiment Station farm for a more exact determination of the relation of soil moisture to crop yield were used again. Barley was sown on the six tanks which were fallow during the year 1903 and those which produced crops in 1903 were allowed to remain fallow during 1904.

Tests were conducted in the field on seven plats of alfalfa, six plats of potatoes, six plats of barley and seven plats of wheat. The water was measured to the plats through a Cippoletti weir 0.6 of a foot in length. Embankments were thrown up around each separate plat to prevent the water from wasting. So that an accurate determination of the actual quantity of water was obtained.

IN YELLOWSTONE VALLEY.

The experiments were a continuation of the experiments of 1903 on the Big Ditch. Daily gage hight observations were made during the entire season and the quantity of water accurately determined. The areas were surveyed by Messrs. Tavenner & Morris by transit and stadia during the summer of 1903.

IN BITTER ROOT VALLEY.

In the Bitter Root Valley the experiments were this year confined to the Bitter Root Stock farm where Mr. M. D. Kippen, engineer, kept records of the daily gage hights and the discharge of seventeen stations. All the work of computation was done in this office and the results were given to Mr. Kippen in exchange for his services.

DRAINAGE INVESTIGATIONS.

In the best farming district in the Yellowstone Valley above Billings there are thousands of acres of land rendered entirely unproductive by the appearance of water and white alkali at the surface of the ground. Wherever these two elements appear at the surface, the crops are entirely destroyed and the milk weed flags and Scotch thistle take their place.

A tract consisting of about 300 acres was selected on the home ranch of the Custer Cattle Company and Ed O'Donnell's ranch about three miles southwest of Billings. It was proposed primarily to drain the water from the land and incidentally remove the alkali. Accordingly topographic surveys were made and a system of drains laid out. These were constructed so far as the time and means at disposal permitted, and the drains thus laid amounting to 10,000 feet in length are working satisfactorily and discharging great volumes of strongly alkali water.

The engineering was done by the irrigation department—the expense being equally borne by the Experiment Station and the U. S. Irrigation and Drainage Investigations. All of the materials for the drains, and the work of digging trenches, pumping, building pipe, and backfilling was done by the Custer Cattle Company and Mr. O'Donnell.

CO-OPERATION WITH THE STATE ENGINEER.

Through an act of the Eighth Legislative Assembly of the State of Montana the office of State Engineer was created. By the provisions of this act he was empowered and required to act in co-operation with the U. S. Geological survey and the Experiment Station. Accordingly an agreement was entered into to gauge the small streams of the Gallatin Valley. The State Engineer furnished \$1000 and the Experiment Station \$200 together with the services of the Irrigation Engineer.

Gauging stations were established on eight of the smaller streams as follows: Little Bear Creek, Big Bear Creek, Cottonwood Creek, Middle Creek, Bozeman Creek, Rocky Canyon Creek, Bridger Creek and Pass Creek.

Sufficient data has not yet been collected to make a rating of the streams and the matter will have to appear in a later report.

DISCHARGE OF THE PRINCIPAL RIVERS OF THE STATE.

Through the kindness of the engineers of the U. S. Reclamation Service and especially of Mr. George E. Stratton, engineer in charge of the Madison River project, and Mr. Stockman, the following tables give the discharge measurements and the estimated monthly discharge of many of the principal rivers in the state.

DISCHARGE MEASUREMENTS OF ST. MARY RIVER AT DAM SITE,
NEAR ST. MARY, MONTANA, IN 1904.

Date	Hydrographer.	Width. Feet	Area of Section. Sq. Feet.	Mean Velocity. Ft. per Second.	Gage Height. Feet.	Discharge. per Second Cubic ft.
May 9.....	L. R. Stockman...	91	202	4.34	3.13	878
June 8.....	W. B. Freeman....	101	360	5.91	4.73	2,130
July 11.....	Robert Follansbee.	100	309	5.73	4.30	1,771
July 24.....	W. B. Freeman...	96	202	4.21	3.20	851
August 31....	W. B. Freeman...	87	135	3.27	2.42	442
November 18.	L. R. Stockman...	49	46	1.34	1.25	62

ESTIMATED MONTHLY DISCHARGE OF ST. MARY RIVER AT DAM SITE,
NEAR ST. MARY, MONTANA, 1902-1904.
(Drainage area 177 square miles.)

Month. 1902.	Discharge in cubic ft. per second.			Total feet. Acre	Run-off.	
	Maximum	Minimum.	Mean.		Cubic ft. per sec. ond per square mile.	Depth in inches.
January a.....			110	6,764	0.62	0.71
February a.....			120	6,664	.68	.71
March a.....			100	6,149	.56	.65
April b.....	223	120	146	8,688	.82	.91
May	4,000	190	1,729	106,312	9.77	11.26
June.....	3,760	950	1,862	110,796	10.52	11.74
July.....	4,360	1,160	2,164	133,059	12.23	14.10
August.....	1,160	565	785	48,267	4.44	5.12
September.....	515	258	342	20,350	1.93	2.15
October.....	258	190	221	13,589	1.25	1.44
November.....	190	127	156	9,282	.88	.98
December.....			130	7,993	.73	.84
The year.....			655	477,913	3.70	50.61

ESTIMATED MONTHLY DISCHARGE OF ST. MARY RIVER AT DAM SITE,
NEAR ST. MARY, MONT., 1902-1904—Continued.

Month.	Discharge in cubic ft. per second.			Total in acre-feet.	Run-off.	
	Maximum	Minimum	Mean		Cubic ft per second per square mile.	Depth in inches.
1903.						
1903.						
January d.....	158	72	93	5,718	.53	.61
February d.....	72	72	72	3,999	.41	.43
March d.....	72	50	57	3,505	.32	.37
April.....	223	72	129	7,676	.73	.81
May.....	2,110	223	743	45,685	4.20	4.84
June.....	3,640	2,110	3,154	187,676	17.82	19.89
July.....	3,280	1,160	1,832	112,645	10.35	11.93
August.....	1,160	675	860	52,879	4.86	5.60
September.....	1,160	465	643	38,261	3.63	4.05
October.....	1,090	465	646	39,721	3.65	4.20
November.....	465	295	379	22,552	2.14	2.39
December e.....	335	295	305	18,753	1.72	1.98
The year.....	3,640	50	743	539,070	4.20	57.10
1904.						
January f.....			120	7,379	.68	.78
February f.....			80	4,602	.45	.49
March f.....			80	4,919	.45	.52
April f.....	740	20	216	12,853	1.22	1.36
May.....	2,110	810	1,220	75,015	6.89	7.49
June.....	2,390	1750	2,021	120,258	11.42	12.74
July.....	1,930	810	1,456	89,526	8.23	9.49
August.....	810	420	689	42,365	3.89	4.48
September.....	620	258	362	21,541	2.05	2.29
October.....	258	127	205	12,605	1.16	1.34
November.....	127	70	91	5,415	.51	.57
December f.....	72	50	51	3,136	.29	.33
The year.....			549	999,614	3.19	44.23

a. Estimated by C. C. Babb.

b. April 1—8, estimated by C. C. Babb.

c. Frozen December 7 to 25, 1902. Mean estimated by C. C. Babb.

d. Probable ice conditions during January, February and March. Rating table has been applied as for open channel.

e. December 11 to 31, 1903, estimated by C. C. Babb.

f. Frozen January 1 to 10, January 20 to April 2, and December 22 to 31. Means for January, February, March, and December estimated by C. C. Babb.

**DISCHARGE MEASUREMENTS OF ST. MARY RIVER AT INTERNATIONAL
LINE, NEAR CARDSTON, ALBERTA, IN 1903 AND 1904.**

Date.	Hydrographer.	Width. Feet.	Area of Section. Sq. feet.	Mean Velocity. Feet per sec.	Feet. Height.	Discharge. Cubic ft. per second.
1903						
May 11.....	F. M. Brown.....	130	270	4.19	4.76	1,131
May 11.....	".....	130	286	3.79	4.76	1,085
May 11.....	".....	130	286	3.93	4.76	1,125
June 5.....	C. T. Prall.....	173	a 680	8.75	7.05	5,953
June 23.....	".....	170	a 590	7.40	6.55	4,406
August 3.....	".....	141	407	4.25	5.20	1,730
October.....	".....	135	351	3.77	4.80	1,325
1904.						
May 10.....	L. R. Stockman.....	132	326	4.10	4.88	1,337
June 9.....	W. B. Freeman.....	161	517	6.36	6.02	3,288
July 12.....	Robert Follansbee.....	153	427	5.78	5.60	2,468
July 30.....	W. B. Freeman.....	135	318	3.81	4.82	1,213
September 3.....	".....	123	232	2.62	4.03	608
November 19....	L. R. Stockman.....	95	119	.80	2.45	96

a. Recomputed, using standard section.

ESTIMATED MONTHLY DISCHARGE OF ST. MARY RIVER AT INTERNATIONAL LINE, NEAR CARDSTON, ALBERTA, 1902—1904.

Month.	Discharge in cubic ft. per second.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Cubic ft. per Sec per sq. Mile.	Depth in inches.
1902.						
September.....	747	198	604	35,940	1.34	1.50
October.....	608	306	477	29,330	1.06	1.22
November.....	410	174	342	20,350	.76	.85
December.....	1,755	255	1,092	67,144	2.42	2.79
The period.....	.....	.....	.....	152,764	.....	.....
1903.						
January a.....	1,105	575	855	52,572	1.89	2.18
February a.....	1,155	410	913	50,705	2.02	2.10
March a.....	2,755	827	1,269	78,028	2.81	3.24
April.....	2,565	365	1,068	63,550	2.36	2.63
May.....	3,060	870	1,720	105,759	3.81	4.39
June.....	6,175	4,075	5,200	309,421	11.50	12.82
July.....	4,855	1,900	2,924	179,790	6.47	7.46
August.....	1,900	1,105	1,404	86,329	3.11	3.59
September.....	2,300	710	1,109	65,990	2.45	2.73
October.....	1,687	575	917	53,384	2.03	2.34
November.....	870	365	535	31,835	1.18	1.32
December.....	675	288	438	26,931	.97	1.12
The year.....	6,175	288	1,529	1,107,294	3.38	45.92
1904.						
January b.....	288	174	224	13,773	.50	.58
February c.....			200	11,504	.44	.47
March c.....			200	12,298	.44	.51
April d.....			935	55,636	2.07	2.31
May.....	3,273	1,260	2,022	124,328	4.47	5.15
June.....	3,493	2,135	2,794	166,255	6.18	6.90
July.....	2,565	1,208	1,860	114,367	4.12	4.75
August.....	1,208	575	931	57,245	2.06	2.37
September.....	640	288	420	24,992	0.93	1.04
October.....	288	144	213	13,097	.47	.54
November c.....	136	109	122	7,260	.27	.30
December c.....	240	128	157	9,654	.35	.40
The year.....	.....	...	840	610,409	1.86	25.32

- a. Probable ice condition January, February and March. Rating table applied as for open channel.
- b. River frozen January 18 to 31, table applied as for open channel.
- c. Mean for month estimated by Mr. C. C. Babb.
- d. Ice gorge April 5 to 10. Mean computed from April 11 to 30 is assumed as mean for entire month.

ESTIMATED MONTHLY DISCHARGE OF SWIFTCURRENT CREEK AT
HENKEL'S RANCH, NEAR ST. MARY, MONTANA, FOR 1903

AND 1904. a
(Drainage area, 101 square miles.)

Month. 1903.	Discharge in Cubic Ft. per second.			Total in acres-ft.	Run-off.	
	Maximum.	Minimum.	Mean.		Cubic ft. per sec. per sq mile	Depth in inches.
January b	67	45	50	3,074	0.50	0.58
February b	52	45	40	2,555	.46	.48
March b	78	45	50	3,074	.50	.58
April	325	40	100	5,950	.99	1.10
May	1,180	162	465	28,592	4.60	5.30
June c	2,630	1,180	1,885	112,165	18.66	20.82
July	1,105	420	708	43,532	7.01	8.08
August	475	325	389	23,918	3.85	4.44
September	1,340	190	421	25,052	4.17	4.65
October	535	190	277	17,033	2.74	3.16
November	740	112	256	15,233	2.53	2.82
December d	219	136	166	10,207	1.64	1.89
The year	2,660	40	401	290,385	3.97	53.90
1904.						
January e			50	3,074	.50	.58
February e			40	2,301	.40	.43
March e			40	2,460	.40	.46
April	810	60	230	16,661	2.77	3.09
May	1,500	420	749	46,054	7.42	8.55
June	1,540	568	972	57,838	9.62	10.73
July	845	348	553	34,003	5.48	6.32
August	348	176	290	17,831	2.87	3.31
September	234	80	128	7,616	1.27	1.42
October	101	20	62	3,812	.61	.70
November e	90	17	36	2,142	.36	.40
December e	36	17	23	1,414	.23	.26
The year	.....	...	269	195,206	2.66	36.25

- a. 1902 rating table applied from January 1 to April 24, 1903. 1904 rating table applied from April 25, 1903-1904, after adding 0.3 foot to gage heights April 25 to June 7, 1903.
- b. Probable ice conditions. Rating table applied as for open channel.
- c. June 8—16 estimated.
- d. December 22—31, estimated.
- e. Means supplied by C. C. Babb. River frozen, with the exception of January 12 to 19, and November 1 to 19.

DISCHARGE MEASUREMENT OF KENNEDY CREEK NEAR WETZEL,
MONTANA, IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section, Sq. Feet..	Mean Velocity, Ft. per Sec	Stage Hight, Feet.....	Discharge, Cubic Ft. per Sec
May 9.....	L. R. Stockman.....	51	58	2.49	6.13	145
June 8.....	W. B. Freeman.....	59	92	3.66	6.63	337
July 12.....	Robert Follansbee.....	59	81	2.04	6.40	165
July 30.....	W. B. Freeman.....	49	46	1.78	6.03	82
September 3.....	W. B. Freeman.....	46	39	1.23	5.87	48
November 18.....	L. R. Stockman.....	37	27	.96	5.61	26

DISCHARGE MEASUREMENTS OF MISSOURI RIVER NEAR TOWNSEND,
MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section, Sq. Feet.....	Mean Velocity, Ft. per Sec.....	Stage Hight, Feet.....	Discharge, Cubic Ft. per Sec.....
April 15.....	A. E. Place.....	431	2,145	3.45	5.12	7,419
May 24.....	W. B. Freeman.....	404	3,475	6.45	7.89	22,405

ESTIMATED MONTHLY DISCHARGE OF THE MISSOURI RIVER NEAR
TOWNSEND, MONT., FOR 1904.
(Drainage area, 14,500 sq. miles.)

Month.	Discharge in Cubic Ft. per second.			Total in acre-ft.	Run off.	
	Maximum.	Minimum.	Mean.		Cubic ft. per Sec. per square mile	Depth in inches.
January.....	.....	.....	*2,700	166,016	0.186	0.214
February.....	.....	.....	*2,700	155,306	.186	.201
March, 15-31 Inc.....	5,260	2,490	6,947	242,692	.272	.314
April.....	13,440	3,950	7,318	435,451	.505	.563
May.....	25,410	10,655	1,672	902,146	1.012	1.167

*Estimated. °Mean for 17 days taken as mean for entire month.

DISCHARGE MEASUREMENTS OF MISSOURI RIVER AT CASCADE, MONTANA, IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section, Sq. Feet..	Mean Velocity ft. per sec....	Gage Hight, Feet.....	Discharge, Cubic Ft. per Sec
April 13.....	A. E. Place.....	373	3,000	2.19	5.52	6,714
May 28.....	L. R. Stockman.....	489	4,823	4.77	9.40	23,026
June 3.....	E. C. Murphy.....	466	4,767	4.29	9.24	20,437
June 11.....	W. B. Freeman.....	466	4,383	4.09	8.45	17,753
July 27.....	".....	366	2,929	1.90	5.15	5,552
August 16.....	".....	342	2,447	1.05	3.90	2,571
September 12.....	".....	348	2,381	.95	3.80	2,255
November 10.....	L. R. Stockman.....		2,664	1.43	4.52	3,805

ESTIMATED MONTHLY DISCHARGE OF MISSOURI RIVER AT CASCADE MONTANA, FOR 1904.
(Drainage area, 18,295 sq. miles.)

Month.	Discharge in cubic ft. per second.			Total in Acre-feet.....	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic Ft. per sec. per Sq. Mile	Depth in Inches.....
January.....	.....	.....	*6,000	308,920	0.328	0.378
February.....	.....	.....	*6,000	345,124	.328	.354
March.....	.....	.....	*6,000	308,926	.328	.378
April.....	12,830	5,150	8,409	500,370	.460	.513
May.....	21,710	12,090	14,925	917,702	.816	.941
June.....	20,600	11,350	16,660	991,339	.911	1.016
July.....	11,350	3,600	7,436	457,222	.406	.468
August.....	3,480	2,305	2,898	178,191	.158	.182
September.....	2,380	1,915	2,167	128,946	.118	.132
October.....	3,600	2,465	2,979	183,172	.163	.188
November.....	3,600	3,260	3,416	203,266	.187	.209
December.....	4,490	2,740	3,597	221,171	.197	.227
The year.....	.....	.....	6,707	4,864,355	.367	4.986

*Estimated.

DISCHARGE MEASUREMENTS OF MADISON RIVER NEAR NORRIS,
MONTANA, IN 1904.

Date.	Hydrographer.	Area of Section, Sq. Feet.	Mean Velocity, feet per sec.	Gage Height, feet.	Discharge, cubic ft. per sec.	Discharge from Cherry Creek*
April 19.....	A. E. Place.....	476	4.18	1.50	1,989	77
May 14.....	W. B. Freeman.....	557	4.28	1.91	2,384	80
June 14.....	".....	854	6.51	2.87	5,558	130
July 6.....	".....	623	5.04	2.10	3,140	73
July 19.....	".....	493	4.43	1.78	2,186	20
August 23.....	W. B. Freeman and.....	397	3.60	1.48	1,427	13
	R. Follansbee.....					
October 28.....	L. R. Stockman.....	404	3.61	1.45	1,459	12

*Add discharge of Cherry Creek to that of Madison to get entire amount passing gage.

ESTIMATED MONTHLY DISCHARGE OF MADISON RIVER (INCLUDING
CHERRY CREEK) NEAR NORRIS, MONT., FOR 1904.
(Drainage area, 2,085 sq miles.

Month.	Discharge in cubic ft. per second.			Total in Acre-feet.	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec.	Depth in Inches
January.....	.....	.....	a 1,200	73,785	0.576	0.664
February.....	.....	.....	a 1,200	69,025	.576	.621
March b.....	1,755	1,100	c 1,288	79,196	.618	.712
April.....	2,010	1,100	1,433	85,269	.687	.766
May.....	6,735	2,010	3,745	230,271	1.796	2.071
June.....	6,735	3,855	5,610	333,818	2.691	3.002
July.....	3,855	1,755	2,667	163,988	1.279	1.475
August.....	1,755	1,410	1,532	94,199	.735	.847
September.....	1,520	1,300	1,355	80,628	.650	.725
October.....	1,410	1,300	1,346	82,762	.646	.745
November.....	1,300	1,300	1,300	77,355	.624	.696
December.....	.....	.....	a 1,200	73,785	.576	.664
The year.....	.....	.....	1,990	1,444,081	.954	12.988

a. Estimated by C. C. Babb.
b. March 6—13 inclusive, March 23, 24, 25, estimated.
c. Mean for 26 days taken as mean for month.

DISCHARGE MEASUREMENTS OF WEST GALLATIN RIVER AT SALESVILLE, MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section, Sq. Feet....	Mean Velocity, Ft. per Sec..	Stage, Height, Feet.....	Discharge, Cubic Ft. per Sec..
May 13.....	W. B. Freeman.....	98	311	4.10	4.21	1,275
May 31.....	W. B. Freeman and E. C. Murphy.....	143	587	7.68	6.33	4,510
June 13.....	W. B. Freeman.....	143	561	7.37	6.16	4,132
July 5.....	W. B. Freeman.....	136	448	5.79	5.18	2,595
July 18.....	W. B. Freeman.....	98	325	4.22	4.23	1,371
August 22.....	W. B. Freeman and... R. Follansbee.....	91	221	2.45	3.34	542
October 27.....	L. R. Stockman.....	87	221	2.22	3.17	491

ESTIMATED MONTHLY DISCHARGE OF WEST GALLATIN RIVER AT SALESVILLE, MONT., FOR 1904.
(Drainage 860 square miles.)

Month.	Discharge, Cubic Ft. per Sec			Total in Acree-feet.....	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic Ft. per sec. per Sq. Mile.	Depth in Inches.....
January	435	335	369	22,689	0.429	0.495
February	435	335	351	20,190	.408	.440
March.....	355	320	336	20,660	.391	.451
April.....	1,310	335	612	36,416	.712	.794
May.....	5,775	1,065	2,563	157,593	2.980	3.436
June.....	5,700	3,000	4,400	261,818	5.116	5.708
July.....	3,525	965	2,053	126,234	2.387	2.752
August.....	920	455	653	40,151	.759	.875
September.....	555	455	506	30,109	.588	.656
October.....	525	435	482	29,637	.560	.646
November.....	435	400	421	25,051	.490	.547
December.....	400	335	372	22,873	.432	.498
The Year.....	5,775	320	1,093	793,421	1.271	17.298

DISCHARGE MEASUREMENTS OF GALLATIN RIVER AT LOGAN, MONT.,
FOR 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section, Sq. Feet..	Mean Velocity, feet per sec	Stage Height, feet.....	Discharge, cubic ft. per sec.
April 16.....	A. E. Place.....	150	556	2.51	2.34	1,399
April 24.....	A. E. Place.....	150	563	2.61	2.45	1,467
May 24.....	W. B. Freeman.....	150	945	5.59	4.98	5,280
May 30.....	W. B. Freeman and E. C. Murphy.....	151	782	4.26	4.08	3,330
June 18.....	W. B. Freeman.....	152	885	4.99	4.71	4,418
June 27.....	W. B. Freeman.....	148	678	3.36	3.30	2,278
July 20.....	W. B. Freeman.....	141	447	1.96	1.83	878
August 20.....	W. B. Freeman.....	137	294	1.00	.78	294

ESTIMATED MONTHLY DISCHARGE OF GALLATIN RIVER AT LOGAN,
MONT., FOR 1904.
(Drainage area 1805 square miles.)

Month.	Discharge, cubic ft. per sec.			Total in Acre-feet.....	Run-off.	
	Maximum	Minimum	Mean		Cubic Ft. per sec. per Sq. Mile.	Depth in Inches.....
January (11-31).....	670	385 ^a	462	28,407	0.256	0.295
February.....	740	300	524	30,141	.293	.316
March.....	880	385	478	29,391	.265	.306
April.....	1,980	435	1,169	69,560	.648	.723
May.....	5,400	1,770	2,772	170,444	1.536	1.771
June.....	4,940	2,205	3,897	231,888	2.159	2.409
July.....	2,325	670	1,290	79,319	.715	.824
August.....	605	230	357	21,951	.198	.228
September.....	740	435	544	32,370	.301	.336
October.....	740	705	738	45,378	.409	.472
November.....	740	740	740	44,033	.410	.457
December.....	955	635	825	59,727	.457	.527
The Year.....	5,400	230	1,150	833,609	0.637	8.664

a. Mean of January 11 to 31 is taken as mean for month.

DISCHARGE MEASUREMENTS OF JEFFERSON RIVER NEAR SAPPING-
TON, MONT., FOR 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section, Sq. Feet.....	Mean Velocity, Ft. per Sec	Gage Hight, Feet.....	Discharge, cubic ft. per sec. . .
April 26.....	A. E. Place.....	270	1,248	4.10	4.40	5,126
May 18.....	W. B. Freeman.....	268	1,360	4.21	4.90	5,727
May 30.....	W. B. Freeman and.....	268	1,457	4.77	5.43	6,949
June 28 a	E. C. Murphy.....					
	W. B. Freeman.....	250	1,041	3.39	3.65	3,533
July 23 a	W. B. Freeman.....	227	762	1.78	2.39	1,358
August 24 a	W. B. Freeman and.....	220	358	1.24	1.45	445
	R. Follansbee.....					
November 1 b	L. R. Stockman.....	260	574	1.80	2.00	1,032

a. From bridge below cable. b. From a new section 300 ft. above old cable station.

ESTIMATED MONTHLY DISCHARGE OF JEFFERSON RIVER NEAR SAPPING-
TONGTON, MONT., FOR 1904.
(Drainage area 8984 square miles.

Month.	Discharge cubic ft. per second.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Cubic ft per sec. per sq. mile	Depth in inches.
January.....	.....	.....	a1,400	86,033	.156	.180
February.....	.....	.....	a1,400	80,529	.153	.186
March b	1,860	1,210	1,433	88,112	.159	.183
April.....	7,150	1,450	3,218	191,434	.358	.399
May.....	9,240	5,060	6,516	400,653	.725	.836
June.....	7,720	2,780	5,410	323,702	.600	.676
July.....	3,445	1,045	2,055	126,357	.229	.264
August.....	1,045	465	606	37,262	.067	.077
September.....	630	545	566	33,679	.063	.070
October.....	1,155	545	824	50,666	.092	.106
November.....	1,580	990	1,303	77,831	.146	.163
December.....	1,720	1,100	1,353	83,193	.151	.174
The Year .....	.....	.....	2,177	1,579,551	.242	3.296

a. Estimated. b. March 10 to 31 inc. Mean for 22 days taken as mean for month.

DISCHARGE MEASUREMENTS OF SUN RIVER (North Fork) NEAR
AUGUSTA, MONT., IN 1903 AND 1904.

Date.	Hydrographer.	Area of Section, Sq. Feet.	Mean Velocity, feet per sec	Gage Hight, Feet.....	Discharge Cubic ft. per sec.
1903.					
November 1.....	C. T. Prall.....	378	1.19	1.00	453
1904.					
July 8.....	A. P. Porter.....	518	2.73	2.42	1,416
July 9.....	A. P. Porter.....	522	2.86	2.45	1,492
July 19.....	A. P. Porter.....	404	1.88	1.70	760
September 8.....	A. P. Porter.....	291	.92	.81	269
November 12.....	L. R. Stockman.....	260	.60	.60	158

DISCHARGE MEASUREMENTS OF SUN RIVER (South Fork) NEAR
AUGUSTA, MONT., IN 1904.

Date.	Hydrographer.	Area of Section Sq. Ft.	Mean Velocity, feet per sec	Gage Hight, Feet.....	Discharge Cubic feet per second.
December 2.....	A. P. Porter.....	51.4	0.45	1.30	233

DISCHARGE MEASUREMENTS OF MARIAS RIVER NEAR SHELBY,
MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Stage Height Feet..	Discharge Cubic Feet Per Sec.
May 8.....	A. E. Place.....	170	546	4.31	4.02	2,359
May 20.....	L. R. Stockman.....	70	603	4.86	4.34	2,934
May 27.....	L. R. Stockman.....	75	611	4.92	4.44	3,004
June 10.....	W. B. Freeman.....	178	604	4.63	4.31	2,798
June 29.....	Robt. Follansbee.....	162	444	4.93	3.35	1,303
August 1.....	W. B. Freeman.....	143	271	1.83	2.44	495
September 5.....	W. B. Freeman.....	135	204	1.13	1.97	231
November 16.....	L. R. Stockman.....	124	199	.93	1.80	184

ESTIMATED MONTHLY DISCHARGE OF MARIAS RIVER NEAR SHELBY,
MONT., FOR 1904.

(Drainage area, 2,610 sq. miles.)

Month.	Discharge in cubic Feet Per Sec.			Total in Acre Feet.....	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec. per sq. mile.	Depth in Inches
January (1-18, inc.)	1,380	900 a	900	55,555	0.345	0.358
February.....	.....	..... a	800	46,016	.307	.331
March.....	.....	..... a	800	49,190	.307	.354
April (1-7,..... estimated).....	8,500	800	2,457	146,202	.911	1.050
May.....	4,900	1,980	2,848	175,117	1.091	1.258
June.....	3,700	1,240	2,495	148,403	.956	1.067
July.....	1,605	435	871	53,553	.334	.385
August.....	490	290	337	22,536	.141	.162
September.....	335	205	246	14,638	.094	.105
October.....	205	185	204	12,544	.078	.090
November b.....	185	150	178	9,997	.064	.071
December.....	.....	..... a	150	9,223	.057	.066
The Year.....	.....	.....	1,017	742,851	.393	5.337

a. Estimated. b. Discharge estimated for November 20--30.

DISCHARGE MEASUREMENT OF TETON RIVER NEAR BELLEVIEW,
MONT., IN 1904.

Date.	Hydrographer.	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
November 27.....	A. P. Porter.....	38.2	1.52	0.60	58.0

DISCHARGE MEASUREMENT OF TETON RIVER NEAR CHOTEAU,
MONT. IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
November 29.....	A. P. Porter.....	15	5.8	1.25	1.8	7.3

DISCHARGE MEASUREMENTS OF MILK RIVER AT HAVRE, MONT.,
FOR 1904.

Date.	Hydrographer.	Width, Feet....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet	Discharge Cubic Feet Per Sec
April 12.....	A. E. Place.....	172	74	3.83	7.78	2,866
May 5.....	A. E. Place.....	168	289	2.03	5.18	588
May 19.....	L. R. Stockman.....	75	124	2.90	4.37	359
May 26.....	L. R. Stockman.....	90	159	1.69	4.43	289
June 4.....	W. B. Freeman and E. C. Murphy.....	155	252	1.73	4.93	435
June 30.....	R. Follansbee.....	62	70	1.34	3.47	95
July 18.....	R. Follansbee.....	56	37	1.19	3.02	44
August 1.....	W. B. Freeman.....	24	11	1.10	2.80	12
August 10.....	W. B. Freeman.....	7	5	.69	2.45	3

ESTIMATED MONTHLY DISCHARGE OF MILK RIVER AT HAVRE,
MONT., FOR 1904.

(Drainage area, 7,300 sq. miles.)

Date.	Discharge in cubic Feet Per Sec.			Total in Acre Feet.....	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec per sq. mile	Depth in Inches
January .....	...	...	90	6,554	0.012	0.014
February .....	...	...	75	4,314	.010	.011
March.....	...	...	75	4,612	.010	.012
April.....	4,900	340	1,736	103,299	.238	.266
May.....	580	230	373	22,935	.051	.059
June.....	490	105	278	16,542	.038	.042
July.....	90	10	44	2,705	.006	.007
August.....	22	0	5	307	.000	.000
September.....	10	1	3	178	.000	.000
October.....	41	3	19	1,108	.003	.003
November.....	51	22	35	2,083	.005	.006
December.....	...	..	25	1,537	.003	.003
The Year.....	...	...	230	165,214	.031	.423

DISCHARGE MEASUREMENTS OF MILK RIVER AT MALTA, MONTANA,
FOR 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
April 8 a	W. B. Freeman.....	150	1,261	2.51	10.45	3,162
April 10.....	W. B. Freeman.....	153	1,962	4.14	14.35	8,116
April 11.....	W. B. Freeman.....	153	1,682	4.16	12.57	7,002
April 12.....	W. B. Freeman.....	145	1,530	4.55	11.94	6,966
April 13.....	W. B. Freeman.....	145	1,536	4.44	12.07	6,830
April 13.....	W. B. Freeman.....	145	1,505	4.35	11.83	6,545
April 15.....	W. B. Freeman.....	145	1,467	4.49	11.82	6,583
April 18.....	W. B. Freeman.....	143	1,077	4.45	9.47	4,798
April 18.....	W. B. Freeman.....	143	990	4.52	8.85	4,475
April 19.....	W. B. Freeman.....	142	830	4.64	7.80	3,853
April 19.....	W. B. Freeman.....	141	736	4.73	7.12	3,483
April 20.....	W. B. Freeman.....	135	575	4.86	6.06	2,792
April 20.....	W. B. Freeman.....	131	485	5.19	5.52	2,470
April 21.....	W. B. Freeman.....	116	386	4.85	4.84	1,871
April 22.....	W. B. Freeman.....	106	333	4.70	4.43	1,566
April 23.....	W. B. Freeman.....	106	327	4.38	4.19	1,432
April 24.....	W. B. Freeman.....	103	321	4.40	4.07	1,408
April 24.....	W. B. Freeman.....	103	321	4.33	4.07	1,390
April 26.....	W. B. Freeman.....	100	313	4.41	4.06	1,381
April 30.....	W. B. Freeman.....	94	262	4.03	3.62	1,056
May 5.....	W. B. Freeman.....	95	236	4.00	3.29	,942
May 5.....	W. M. Neptune.....	98	238	3.57	3.29	,850
May 17.....	R. Follansbee.....	86	160	2.66	2.42	,425
May 25.....	R. Follansbee.....	83	130	2.52	2.20	327
June 4.....	W. B. Freeman and E. C. Murphy.....	87	146	3.45	2.37	,503
June 6.....	R. Follansbee.....	138	476	4.59	5.35	2,182
June 7.....	R. Follansbee.....	135	468	4.97	5.08	2,324
June 9.....	R. Follansbee.....	110	318	4.34	3.98	1,382
June 13.....	R. Follansbee.....	93	196	3.07	2.90	601
June 15.....	R. Follansbee.....	92	188	3.12	2.86	588
July 5 b	R. Follansbee.....	22	21	2.09	1.34	44
July 9 b	R. Follansbee.....	20	19	1.00	1.06	19
July 20 b.....	R. Follansbee.....	18	14	.41	.90	6.6
July 28.....	R. Follansbee.....	..	...	...	.71 c	1

a. Ice gorge. b. by wading at different sections. c. estimated.

ESTIMATED MONTHLY DISCHARGE OF MILK RIVER AT MALTA, MONTANA, FOR 1904.

(Drainage area, 14,044 sq. miles.)

Month.	Discharge in cubic Feet Per Sec.			Total in Acre Feet..	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec per sq. mile.	Depth in inches
January .....	.....	...	a 10	6,149	0.001	0.008
February .....	.....	...	a 80	4,602	.006	.006
March.....	.....	...	a 80	4,919	.006	.007
April b	8,794	100	3,268	194,460	.233	.260
May.....	1,118	214	565	34,740	.040	.046
June.....	2,190	45	552	32,846	.039	.044
July.....	45	1	17	1,045	.001	.001
August.....	1	0	1	61	.....	.....
September.....	0	0	0	0	.....	.....
October.....	0	0	0	0	.....	.....
November.....	45	0	14	833	.001	.001
December.....	24	15	15	922	.001	.001
The Year.....	.....	...	391	280,577	.028	.374

a. Estimated. b. April 1—10 inclusive, estimated.

DISCHARGE MEASUREMENT OF MUSSELSHELL RIVER NEAR SHAWMUT, MONT., IN 1904.

Date.	Hydrographer.	Area of Section Square feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet.	Discharge Cubic Feet Per Sec
November 8.	L. R. Stockman.....	53.4	1.38	1.15	74.0

DISCHARGE MEASUREMENTS OF YELLOWSTONE RIVER NEAR LIVINGSTON, MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
April 23.....	A. E. Place.....	190	642	3.44	2.68	2,206
May 16.....	W. B. Freeman.....	184	1,009	4.91	4.77	4,957
June 2.....	W. B. Freeman.....	274	2,002	8.70	8.42	17,418
June 23.....	W. B. Freeman.....	278	2,138	9.62	8.94	20,573
June 25.....	W. B. Freeman.....	278	1,927	7.80	8.02	15,034
July 11.....	W. B. Freeman.....	274	1,687	7.55	7.16 a	12,736
July 26.....	W. B. Freeman.....	189	1,250	6.14	5.78 b	7,677
August 20.....	W. B. Freeman.....	184	894	4.62	4.19	4,130
September 13.....	W. B. Freeman.....	181	738	3.79	3.34	2,794
October 26.....	L. R. Stockman.....	171	577	3.30	2.54	1,904

a. Discharge of overflow, 258 cubic feet per second.

b. Discharge of overflow, 10 cub. ft. per second.

ESTIMATED MONTHLY DISCHARGE OF YELLOWSTONE RIVER NEAR LIVINGSTON, MONT., FOR 1904.

(Drainage area, 3,580 sq. miles.)

Month.	Discharge in cubic Feet Per Sec.			Total in Acre Feet..	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec per sq. mile	Depth in inches
January	1,385	1,045	1,211	74,462	0.338	0.390
February	1,430	1,045	1,256	72,246	.351	.378
March.....	1,745	1,250	1,460	89,772	.408	.470
April.....	3,615	1,475	2,102	125,078	.587	.655
May.....	19,930	3,280	8,446	519,324	2.359	2.720
June.....	19,930	13,590	17,291	1,028,886	4.830	5.389
July.....	16,405	6,280	11,069	680,607	3.092	3.565
August.....	6,695	3,445	4,604	283,089	1.286	1.483
September.....	3,615	2,380	2,749	163,577	.768	.857
October.....	2,220	1,880	2,030	124,820	.567	.654
November.....	1,880	1,520	1,653	98,360	.462	.515
December.....	1,880	900	1,388	85,345	.388	.447
The Year.....	19,930	900	4,605	3,345,566	1.286	17.523

DISCHARGE MEASUREMENTS OF YELLOWSTONE RIVER NEAR BILLINGS, MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
July 10.....	R. S. Stockton.....	452	4,719	4.64	8.40	21,907
July 20.....	R. S. Stockton.....	419	3,230	3.80	6.05	12,289
August 18.....	W. B. Freeman.....	332	2,542	3.53	4.33	8,963
September 16.....	W. B. Freeman.....	320	2,069	2.46	2.90	5,086
September 27.....	R. S. Stockton.....	335	1,974	2.18	2.53	4,305
October 21.....	L. R. Stockman.....	...	1,838	2.24	2.53	4,124

ESTIMATED MONTHLY DISCHARGE OF YELLOWSTONE RIVER NEAR BILLINGS, MONT., FOR 1904.

(Drainage area, 11,180 sq. miles.)

Month.	Discharge in Cubic Per Second.			Total in Acre Feet.....	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec per sq. mile	Depth in inches
June.....	32,580	19,840	25,972	1,545,441	2.323	2.592
July.....	25,475	11,995	18,088	1,112,188	1.618	1.865
August.....	12,265	6,325	8,257	507,703	.738	.851
September.....	8,410	4,145	5,240	311,802	.469	.523
October.....	4,590	3,720	3,973	244,290	.355	.409
November.....	3,720	3,225	3,420	203,504	.306	.311
December.....	3,225	2,740	2,906	178,683	.260	.300
The Period .....	.....	.....	.....	4,103,611	.....	...

DISCHARGE MEASUREMENTS OF YELLOWSTONE RIVER AT GLEN-
DIVE, MONT., IN 1904.

Date.	Hydrographer.	Width, Feet....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet.	Discharge Cubic Feet Per Sec
April 22.....	A. E. Place.....	649	3,617	2.96	2.44	10,718
May 17.....	W. B. Freeman.....	738	4,631	3.32	4.11	15,396
June 1.....	W. B. Freeman and..	760	7,260	5.78	7.42	41,982
	E. C. Murphy.....					
June 24.....	W. B. Freeman.....	1,035	9,722	6.71	9.21	65,224
July 12.....	W. B. Freeman.....	700	6,958	5.37	7.02	37,364
July 25.....	W. B. Freeman.....	744	5,569	4.16	5.28	23,162
August 19.....	W. B. Freeman.....	732	4,117	2.98	3.35	12,250
September 19.....	W. B. Freeman.....	721	2,917	2.33	1.89	6,792
October 22.....	L. R. Stockman.....	727	2,787	2.32	1.64	6,474

ESTIMATED MONTHLY DISCHARGE OF YELLOWSTONE RIVER AT
GLEN DIVE, MONT., FOR 1903 AND 1904.

Drainage area, 66,090 sq. miles.)

Month.	Discharge in Cubic Feet Per Sec.			Total in Acre Feet.....	Run-off.	
	Maximum.....	Minimum.....	Mean.....		Cubic ft. per sec per sq. mile	Depth in inches
1903						
March (16-31, inc.)	20,610	15,480	17,550	556,958	.266	0.158
April.....	39,150	4,600	6,208	369,343	.094	.105
May.....	22,550	4,700	10,775	664,066	.163	.188
June.....	62,300	10,550	40,594	2,415,629	.614	.685
July.....	61,000	16,550	28,089	1,726,818	.425	.490
August.....	30,200	7,780	14,012	861,564	.212	.244
September.....	10,150	6,075	7,737	460,384	.117	.130
October.....	7,510	5,900	6,860	421,805	.104	.120
November (1-15, inc.).....	5,900	5,750	a5,750	339,471	.087	.097
December.....	.....	.....	a5,700	350,479	.086	.099
The Period .....	.....	.....	.....	8,166,517	....	.....
1904.						
January .....	.....	.....	a5,700	350,479	.086	.099
February .....	.....	.....	a5,700	327,868	.086	.093
March.....	.....	.....	a5,700	350,479	.086	.099
April 2-30, inc.) b	48,000	7,780	13,936	829,250	.211	.235
May.....	66,200	12,190	27,002	1,660,288	.409	.472
June.....	77,900	39,150	54,882	3,265,706	.830	.926
July.....	51,900	21,890	33,500	2,059,836	.507	.584
August.....	21,240	9,020	12,698	797,371	.196	.226
September.....	14,705	5,985	8,273	492,278	.125	.139
October (1-23, inc.).....	7,510	5,750	.....	.....	.....	.....
December (1-5,) c .....	.....	.....	7,710	76,463	.117	.022
The Period.....	.....	.....	.....	10,210,017	....	.....

a Estimated by C. C. Babb.

b. Mean for 29 days taken as mean for the month.

c River frozen December 6 to 31.

DISCHARGE MEASUREMENTS OF PRYOR CREEK AT HUNTLEY, MONT.,
IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
August 6 a	R. S. Stockton.....	18	6	1.00	1.00	6
September 17	W. B. Freeman.....	18	10	1.40	1.25	14

DISCHARGE MEASUREMENTS OF BIGHORN RIVER AT FORT CUSTER,
MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet Per Sec
July 16.....	R. S. Stockton.....	438	2,655	3.91	9.00	10,379
July 27.....	R. S. Stockton.....	438	2,357	3.76	8.30	8,867
September 17.....	W. B. Freeman.....	427	1,376	1.50	6.00	2,069
October 1.....	R. S. Stockton.....	426	1,295	1.25	5.69	1,615
October 24.....	L. R. Stockman.....	418	1,310	1.28	5.65	1,673

DISCHARGE MEASUREMENTS OF LITTLE MISSOURI RIVER AT ALZADA, MONT., IN 1904.

Date.	Hydrographer.	Width, Feet.....	Area of Section Square Feet.	Mean Velocity Feet Per Sec.	Gage Hight Feet..	Discharge Cubic Feet per Sec.
April 3.....	F. M. Madden.....	54	218	1.72	5.70	376.
April 3.....	F. M. Madden.....	50	176	1.73	4.90	305.
May 9.....	F. M. Madden.....	21	52	1.60	2.50	83.
May 10.....	F. M. Madden.....	21	46	1.35	2.20	62.
June 26.....	F. C. Magruder.	18	29	.38	1.40	11.
July 8.....	F. M. Madden.....	9	4.6	1.00	1.25	4.6
July 9.....	F. M. Madden.....	14	3.7	1.16	1.20	4.3
September 5.....	F. M. Madden.....	23	67.	1.22	2.90	82.

ESTIMATED MONTHLY DISCHARGE OF LITTLE MISSOURI RIVER NEAR ALZADA, MONT., FOR 1904.

Month.	Discharge in Cubic Feet per Second.			Total in Acre Feet.....
	Maximum.....	Minimum.....	Mean.....	
April.....	1,185	4.	127	7,557
May.....	280	4.	51.6	3,173
June.....	1,744	7.	314	18,680
July.....	31	2.	7.1	437
August a	27	0.	2.0	123
September a	488	0.	30.0	1,785
October a	37.	0.	4.1	252
November a	1.4	1.4	1.4	83
The Period.....				32,090

a. Estimates August 30 to November 30 approximate.

ACKNOWLEDGEMENTS.

The writer desires to express thanks to Mr. C. D. Flaherty, Assistant, Mr. M. D. Kippen, Irrigation Engineer of the Bitter Root Stock Farm, at Hamilton, Montana, Mr. L. R. Stockman, Assistant Engineer U. S. Reclamation service and Mr. Geo. E. Stratton, Engineer of the Reclamation Service.

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**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION.**

F. B. LINFIELD, Director.

**TWELFTH ANNUAL
REPORT**

**FOR
THE FISCAL YEAR ENDING
JUNE 30th, 1905.**

BOZEMAN, MONTANA

FEBRUARY

1906

The Station

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION

BOZEMAN, MONTANA

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- F. B. LINFIELD, B. S. A., *Director and Animal Industry*
- R. A. COOLEY, B. Sc., *Entomologist*
- V. K. CHESNUT, B. Sc., *Chemist*
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- EDMUND BURKE, *Meteorologist and Assistant Chemist*
- FRANK HAM, M. S., *Assistant Chemist*

Post Office, Express and Freight Station, Bozeman.
 All communications to the Experiment Station should be addressed to
THE MONTANA EXPERIMENT STATION,
 Bozeman, Mont.

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

LETTER OF TRANSMITTAL.

Bozeman, Montana, December 31, 1905.

To His Excellency, Joseph K. Toole,
Governor of Montana.

Dear Sir:—In accordance with the Congressional Act of March 2, 1887, I have the honor to transmit herewith the twelfth annual report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1905, the results of investigations of the several departments are reported to the end of the State year, November 30, 1905.

Very respectfully,

F. B. LINFIELD,
Director.

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REPORT OF THE TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1904-1905,

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1905, as per Act of Congress, approved March 2, 1887.....\$ 15,000.00

Cr.

By Salaries	\$ 10,701.68
Labor	1,483.99
Publications	734.06
Postage and Stationery	430.81
Freight and Express	397.11
Heat, Light, Water and Power.....	29.90
Chemical Supplies	115.70
Seeds, Plants and Sundry Supplies.....	338.77
Fertilizers	
Feeding Stuffs	
Library	69.83
Tools, Implements and Machinery.....	70.85
Furniture and Fixtures	96.02
Scientific Apparatus	510.28
Contingent Expenses	15.00
Total.....	<u>\$ 15,000.00</u>

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June, 30, 1905; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00; and the corresponding

disbursements \$15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress, approved March 2, 1887.

Signed,

J. M. ROBINSON,
PETER KOCH, Auditors.

Attest: Peter Koch, Custodian.

SUPPLEMENTARY STATEMENT.

Experiment Station Miscellaneous Fund.

Dr.

To Receipts, Farm Produce, etc. \$4,581.86

Cr.

By Salaries	\$-1,000.00
Labor	1,393.70
Publications.....	
Postage and Stationery	
Freight and Express	
Heat, Light and Water	
Chemical Supplies.....	
Seeds, Plants and Sundry Supplies.....	
Fertilizers .....	.93
Feeding Stuffs	346.90
Library.....	
Tools, Implements and Machinery	
Furniture and Fixtures	
Scientific Apparatus	
Live Stock	1,434.00
Traveling Expenses.....	107.67
Contingent Expenses	
Buildings and Repairs	288.76
Total	<u>\$4,581.86</u>

REPORT OF THE DIRECTOR.

The work of the Experiment Station is, I believe, gradually yet surely growing in its influence and in the confidence of the people of the state. In a state as large as that of Montana, with a great variety of soil and climate, a new agricultural state with new and intricate problems, and with an increasing agricultural population, many of them new to our conditions, there is an increasing demand on the Experiment Station for information of all kinds. This increased demand is manifested in a rapidly increasing correspondence, increased demand for Farmers' Institute work, and for special talks at farmers' horticultural and live stock meetings; also in the demand for the study of special problems in various parts of the state.

The funds of the Montana Experiment Station have come from four sources. The Hatch fund from the United States government, \$15,000.00 per year; the State fund, for maintenance, \$5,000.00, and for experimental purposes, \$1,000.00; from the Northern Pacific railway, for co-operation tests on the dry bench lands, we got last year \$2,500.00, and for the same purpose from the Irrigation Division, United States Department of Agriculture, \$1,000.00. For the coming year the Northern Pacific contributes \$2,500.00 and the Great Northern \$2,000.00 for these dry land tests.

Some of these funds are restricted to special purposes. For instance, the Hatch Act says: "That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies of the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under the varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of

food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states and territories."

The money received from the state for experimental purposes and that contributed by the Northern Pacific and Great Northern railways can only be used for the test on the dry bench lands.

The State Maintenance fund may be used for any purpose where needed.

The ultimate end of all the Station work is to gather new facts that will aid in making more efficient, more profitable and more enjoyable the work of the farm. As our work increases and develops we hope to be able to answer more fully and more intelligently the many questions which the farmers of the state are asking themselves and us every day of the year.

For the past few years the most of the funds from the state have been put into getting the plant in shape to enable the men in charge to do their best work. While this work of further equipment is in no wise completed, yet we have come to a time when the whole of the energies of the Station must be centered on the work it was designed to do. We may not publish any greater number of bulletins in the future than in the past, but we hope to make each one record some fact or facts that shall be a wholly new addition to our fund of knowledge about the methods of successful practice of agriculture in the state.

IMPROVEMENTS.

During the past summer the Experiment Station building received a thorough overhauling, which has materially improved its internal appearance and has given more room for work. The attic has been divided into two rooms, one for a class room and the other for storage of museum material. On the east side of the second floor the botanical material has been moved out and the rooms made into a laboratory for the biological work. On the first floor the toilet room has been moved to the basement and the space added to

the adjoining room, which has been made into a reading room and library. The civil engineering department has been moved into quarters provided by the College and the east rooms on this floor given to the horticultural department. All the rooms in the basement, except one used for a bulletin mailing room, have been fitted up for the agronomy department.

Two additions were made to the buildings of the Station during the year, first, a small green house, 9x16 feet for an insectory for the entomological department, which cost \$225.00, and, second, a poultry building 12x128 feet, with fencing for yards, which cost about \$600.00. A description of this building will be given later in this report. In addition to the above some time and money were spent in fencing yards for the poultry, and hogs, and a beginning was made in draining the few acres of wet land on the farm.

For some years a few pure bred sheep have been kept on the Station farm, but these have been disposed of, as we had no facilities for taking proper care of them or for carrying on any experiments with them.

WORK OF THE DEPARTMENTS

The work of the various departments has progressed along similar lines to those of the year before. No new work was undertaken, but some new phases of the old problems have been investigated.

The Chemical department followed up the work started the year before with locoed sheep. A band of these were treated with vermifuges and then fed a fattening ration during the winter and spring, the feeding being done by the Animal Industry department. The results were very encouraging and the facts of the test are now being prepared for a bulletin. This work was carried on in co-operation with the Bureau of Plant Industry U. S. Department of Agriculture.

The decision to build a sugar beet factory at Billings revived the interest in sugar beet culture over the state, and has increased the demand for co-operative studies along this line.

The study of the foods offered in the market has been taken up

on somewhat of a new line and attention devoted to the study of those products that enter into competition with the Montana products.'

With the reorganization of the work in botany and entomology and the placing of this under one head to be known as biology, some little time was needed to get the work arranged on this new basis. Considerable less money was put into this department for the year, and much time was spent in re-arranging the quarters and getting the insect and plant collections in better working shape. A new line of work was taken up in a preliminary study of the insects affecting sugar beets. One bulletin has been prepared by the department during this year—No. 62, the Third Annual Report of the State Entomologist.

The Horticultural department has extended its work during the year and has taken up some studies in the Bitter Root valley on the effect of thinning the fruit on the tree, on the size of the apples and of the crop. In the same valley, also, studies were undertaken on the effect of cultivation and various methods of cropping on the thriftiness and fruitfulness of the orchard.

On the Station farm tests were continued on the testing of various varieties of vegetables and in the acclimatizing of varieties making them better suited to Montana's climatic conditions. Methods of cultivation and management have also been considered.

The work inaugurated the previous year on the originating and study of new fruits and in collecting and study of native shrubs and ornamental trees has been and will be continued. One bulletin has been issued by the department—No. 60, on Onion Growing.

Because of the changes in the personnel of the Irrigation department, Prof. Baker resigning in the spring and Prof. Tannatt starting in the fall, nothing more than the maintenance of the work on hand was attempted. Observations were continued on the drainage work near Billings and on the duty of water on the farm of J. E. Morse at Dillon. Prof. Tannatt has devoted his time for the latter part of the year to the study and classification of the records in the office and to getting acquainted with irrigation conditions over the state.

The work of the Agricultural department has been expanded during the year, the divisions of Agronomy and Dairying being

separated from the Animal Industry and made departments.

In the Animal Industry department work has been continued in feeding experiments with steers, sheep and hogs. The results of these experiments have been reported in Bulletins 57, 58 and 59. Work in these same directions will be continued next year.

The poultry division of the Animal Industry department has devoted considerable funds to getting the buildings, grounds and stock into shape for doing experiment work. This division of the work will start the new season in excellent shape. Two feeding tests with young cockrels were conducted during the year, and in several pens trap nests have been used to get the egg record of the birds and this has been used as a basis in breeding up the flock.

The head of the Dairy department has devoted some time to studies on ripening of cream, and considerable time has been spent in looking after the live stock experiments during the absence of the head of the Animal Industry department. During the coming year it is planned to devote some time to the study of dairy conditions over the state and to aid and encourage the development of the industry.

The department of Agronomy during the year completed its plans on laying out the farm, and extended its work on the study of varieties of grain and fodder crops. For the coming season systematic work will be taken up on plant breeding, fertility of soil, and rotation of crops. In many parts of the state corn is a successful crop, but work is needed in systematic improvement and acclimation of varieties. Work in this direction will be undertaken in the Yellowstone valley. Climatic conditions in Montana are favorable to the growing of large crops of seeds and grains and of the very best quality. Systematic endeavors will be made to show what can be done in building up the seed business by developing improved varieties and working out methods of management.

SUB-STATIONS.

Last year, through the co-operation of the Northern Pacific railway and the irrigation division of the U. S. Department of Agriculture, we were able to materially increase the work at sub-stations over the state. The principal line of work was to test the

methods of cultivation and the kinds of crops that would give largest returns on the bench lands of the state without irrigation. It was also desired to show how these dry benches might be made desirable and profitable for homes, first, by constructing a small irrigation plant to irrigate the surroundings of the house and farm buildings, and second, to find out by observation through a series of years what area of land without irrigation would make a desirable farm unit.

The funds given by the Northern Pacific railway were \$2,500.00 and by the Irrigation division of the Department of Agriculture \$1,000.00, and this was supplemented by an appropriation of \$1,000.00 given by the state, making a total of \$4,500.00. Four sub-stations were started, viz: At Fort Irteen Mile, near Glendive, at Miles City, at Helena and at Dillon. In addition to this the work was continued near Great Falls. There is a great need for this work as there are millions of acres in the state that are permanently above the ditch. The land cannot be irrigated because the water cannot be got to it, or there is no water available. We hope to extend this work and to be able to carry on the investigations for several years.

FARMERS' INSTITUTES.

The Farmers' Institute work has increased largely during the year, and the increased interest in the work is shown by the increased attendance and the increased calls for meetings. In a new agricultural country such as Montana is we lack a trained body of Farmers' Institute workers. For this reason the Station officers are in large demand for this work. This has been a means of bringing the College and its work very prominently before the people and has had a value to the Station officers in permitting them to get acquainted with the people and the agriculture of all parts of the state. As the Director of the Station is the Superintendent of Farmers' Institutes, it will be our plan to so arrange this work as to make it of greatest value to the people of the state and of the Station officers without permitting it to interfere with the original investigations that these men should be doing.

CO-OPERATIVE EXPERIMENTS

The work of the Montana Experiment Station was very materially helped and extended during the year by funds contributed for co-operation experiments. Without this help several lines of work could not have been undertaken.

For some years co-operative experiments have been carried on with the irrigation division of the U. S. Department of Agriculture in studying the irrigation problems of the state. For the past year a new direction was given to the help from this division, the funds contributed, \$1,000.00, being used in connection with the dry farm tests taken up with the Northern Pacific railway.

The Northern Pacific railway owns large tracts of land in the state, which, from the studies carried on in other states, it seemed to the management could be profitably farmed if proper methods were followed. As a result they asked the U. S. Department of Agriculture and the State Station to take up this problem. To help along this work they contributed \$2,500.00 towards the expenses of the work.

In the study of the available water supply of the state the State Engineer entered into arrangements with the Experiment Station to make studies of the small streams in Gallatin valley. The State Engineer's office contributed \$1,000.00 towards this work.

The Bureau of Plant Industry of the U. S. Department of Agriculture has also undertaken co-operative experiments with the Station in the study of cause and cure or prevention of the so-called Loco poisoning of sheep. This work was undertaken with the Chemical department of the Station. A pathologist, Dr. Marshall, was sent to the state and funds were also contributed for the purchase and care of 100 sheep needed in the experiment. The Experiment Station and the state are under many obligations for the generous help contributed and the aid given in extending our work.

STATION STAFF.

There were several changes in the Station staff the past year, but none which affected the continuity of the experiment work.

Dr. J. W. Blankenship, who, for several years, was botanist of the Station, severed his connection with the Station at the end of

the fiscal year. During the seven years Dr. Blankenship was connected with the Station he got together a most excellent and very extensive collection of plants and a very complete flora of the northern inter-mountain region.

In view of this resignation the work in botany and zoology was combined in a new department of biology, with Prof. R. A. Cooley, the Station Entomologist, as head of the department.

Prof. J. S. Baker, who spent several years as assistant to Prof. Fortier, and who was last year advanced to the head of the Irrigation department, resigned in the spring to accept a more remunerative position with the state engineer. While not connected with the Station, Mr. Baker's training and experience are yet available to the state. Mr. E. Tappan Tannatt, of Spokane, Washington, was elected to the position of irrigation engineer in September. He brings to the work ripe experience in practical engineering.

Mr. James Dryden, who was engaged last year to take charge of the poultry work, severed his connection with the Station in the spring to take up the poultry work in a business way in the east. The poultry work will remain as a division of the Animal Industry department.

A more complete division of the work has been made in the Agricultural department. The assistants in Agronomy and Dairying, viz: A. Atkinson and W. J. Elliott, were advanced and their work given full department rank.

In the Chemical department, Mr. H. J. Reese, assistant chemist, resigned.

NEEDS OF STATION.

A pressing need of the Station is more room. The cramped quarters in the present Experiment Station is used for College and Station work by four departments of the College and Station, besides the Director's office, and the library and mailing room of the Experiment Station. When a building 45x50 feet, two stories with a basement and attic, has to accommodate all the technical agriculture and horticulture, the botany and zoology, subjects, every one of which requires large laboratory room, it is surprising that so efficient work has been done in the past. These departments can-

not do the work which is being demanded of them in these cramped quarters, and it is hoped that this fact will be recognized by our legislators in the very near future and more commodious quarters provided.

When, in connection with this, we note the encouraging prospect for additional funds from the federal government for Experiment Station work, which, if made available, will double the Station funds within a few years, increased room is an absolute necessity if we are to make efficient use of these funds, and also properly provide for the College students.

A beginning has been made in providing increased room and facilities for our live stock and farm products. Ordinarily it might seem that we might be able to get along for a few years with these additions. When it is remembered, however, that two or three years ago there were no farm buildings of a permanent character on the place and the temporary shacks we have are not alone rough looking, but wholly inadequate for our work, it will be recognized that additions are yet needed and should be provided as soon as possible.

In this connection, sheep and steer feeding buildings are our greatest need, though a new horse barn and cottages for the foreman of the farm, livestock, poultry and orchard are needed as these men must be on the ground to give to their work the attention it demands.

CORRESPONDENCE.

The correspondence of the Experiment Station continues to increase; so much so in fact that it is quite a tax on the time of several of the departments. In the last annual report the letters sent out totaled 3700. For the past year they total 4480, an increase of 780 for the year. In addition to the time of answering the letters many of the replies called for considerable research. This mass of correspondence together with the other office work is now more than one clerk can handle and will compel the employment of additional help for next year.

By departments the letters were as follows: Director's Office

1,300, Biology 400, Chemistry 550, Agronomy 700, Dairy 600, Poultry 200, Irrigation 400, Horticulture 330.

PUBLICATIONS OF THE YEAR

Seven bulletins and an annual report make up the publications of the year. They contain 300 pages of printed matter and 5 plates. The list follows:

Bulletin No. 56,—Native Economic Plants of Montana, by J. W. Blankenship. This bulletin gives a list of the native plants used by the Indians and early settlers as food or medicine. There is appended a Bibliography, a list of the plants classified according to use, and a complete index of the common names of the plants.

38 Pages

Bulletin No. 57,—Feeding Pigs. This is a report of five experiments in feeding pigs on a grain ration with various supplimented foods, as milk, clover, roots, and pasture.

18 Pages.

Bulletin No. 58,—Fattening Cattle. This bulletin gives the results of experiments in feeding two car loads of steers, one fed during the winter of 1903-4 and the other during the winter of 1904-5.

26 Pages.

Bulletin No. 59,—Sheep Feeding. In this bulletin is recorded the results of feeding in 1903-4 a deck of lambs and a deck of wethers and a record of the experience of shipping them to Chicago. Also the results of feeding a mixed lot of sheep during the winter of 1904-5.

24 Pages.

Bulletin No. 60,—Onion Growing (a preliminary test). This bulletin reports the results of three years experiments in growing onions. It gives an account of varieties adapted to Montana conditions and outlines methods of growing them successfully.

16 Pages.

Bulletin No. 61,—Food Adulterations, by F. W. Traphagen. This is a very complete presentation of the subject of food adulterations. It gives the opinions of a large number of experts on the damage and danger from food adulterations and the results of analyses of food products offered in the markets of the state.

48 Pages.

Bulletin No. 62,—The Third Annual Report of the State Entomologist. This gives a fairly complete write-up of the Codling Moth

in Montana. It discusses the Plum gouger, and the Corn Worm, and a few other insects that are troublesome at the present time over the state. 48 Pages, and 4 Plates

12th Annual Report,—71 pages and 2 plates.

MAILING LIST.

The Bulletin mailing list of the Experiment Station is increasing rapidly and at present is within a few hundred of 5,000. Of this amount there are 2984 bulletins distributed in the State, 700 are sent to the Agricultural Colleges, the Experiment Stations and allied Institutions throughout the U. S. 195 are sent to the farmers and others interested in our work in other states, and 27 are sent to the Foreign Countries.

We are at present publishing an edition of 5000 copies of each bulletin. This will have to be increased for the coming year, by at least 1000.

LIST OF STATION PUBLICATIONS.

1. Organizations—Announcements.
2. Smuts of Wheat, Oats and Barley.
- * 3. Pig Feeding.
- * 4. Glanders.
- * 5. First Annual Report, Crop Statistics of Gallatin County.
- * 6. Measurement of Water.
- * 7. Small Grains and Potatoes.
- * 8. Second Annual Report—Crop Statistics of Gallatin County—
Parasitic Ictero—Haematurhia of Sheep.
- * 9. Potatoes.
- * 10. Small Grains, Wheat, Oats, Barley.
- * 11. Devices for Obtaining a Constant Flow in Laterals with Variable Heads in the Main Canals or Reservoirs.
12. Third Annual Report, Spaying of Mares.
13. Drinking Water.
14. Montana Swine Feeding.

15. Larkspur Poisoning of Sheep.
16. Fourth Annual Report.
17. An Army Cut Worm—The Grain Aphis.
- *18. The Alkali Soils in Montana.
- *19. The Sugar Beet in Montana.
- *20. Fifth Annual Report.
- *21. Sheep Feeding.
- *22. Thirteen Botanical Subjects.
- *23. Injurious Fruit Insects; Insecticides; Insecticide Apparatus.
- *24. Sixth Annual Report.
- *25. Paris Green, and London Purple.
- *26. Poultry Raising.
- *27. Live Stock Feeding Tests, Beef Cattle, Lambs and Swine.
- *28. Seventh Annual Report.
- *29. Quantity of Water Used in Irrigation.
- *30. Weeds of Montana.
- *31. Report of Grazing and Feeding Tests, Beef Cattle and Lambs.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
34. Farmers' Weirs.
35. Report of Feeding Tests.
36. Forage Conditions in Central Montana.
37. Pork Production in Montana.
38. Food Adulterations.
- *39. Sheep Feeding in Montana.
40. Root Crops in Montana.
41. Sugar Beets, (1902.)
42. The Codling Moth.
- Ninth Annual Report.
43. The Duty of Water.
44. Apple Growing in Montana.
45. The Loco, and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
49. Contagious Abortion in Montana.
- *50. Poultry Management and Poultry Diseases.
51. First Annual Report of the State Entomologist.
- Eleventh Annual Report.

52. Sugar Beets.
53. Creameries and Cheese Factories:
54. The Alkali Soils of Montana.
55. Second Annual Report of the State Entomologist.
Eleventh Annual Report.
56. Native Economic Plants of Montana.
57. Feeding Pigs.
58. Fattening Cattle.
59. Sheep Feeding.
60. Onion Culture.
61. Food Adulterations.
62. Third Annual Report of the State Entomologist.
Twelfth Annual Report.

*Out of Print.

DONATIONS AND LOANS.

- Bureau of Plant Industry, U. S. Dept. of Agriculture. 100 lbs.
sugar beet seed (Kleinswanzleben). 10 lbs. Fenugrek seed.
- Mr. H. Cordes, Chicago, Illinois. 50 lbs. beet seed (Aderstedt).
50 lbs beet seed (Mangold).
- Dr. D. A. Brewer & J. E. McLaughlin, Gebo, Montana. 20 lbs.
Bentonite.
- J. I. Case Threshing Machine Co., Racine, Wisconsin. 1 16-horse
power traction engine.
- Fuller-Johnson Mfg. Co., Madison, Wisconsin. One 8-horse power
gasoline engine.
- John Deere Plow Co., Moline, Illinois. One 16-inch riding plow.
- Aspinwall Manufacturing Co., Jackson, Michigan. One potato
cutter. One potato planter.
- J. D. Tower Co., Mendota, Illinois. One surface corn cultivator.
- The Thos. O'Hanlon Co., Chinook, Montana. Five pounds blue
joint seed.
- The Park-Davis Co., Detroit, Michigan. 30 samples dry culture
Lactic acid for starters.
- Elov Ericsson, 507 Court Block, St. Paul, Minnesota. 30 Samples
Ericsson's butter culture.

The Creamery Package Manufacturing Co., Minneapolis, Minnesota. One 75-gallon Disbrow churn.

New York Dairy & Machine Construction Co. One Sanitary milk pump loaned to us during the winter short course.

The Union Steam Pump Co., Battle Creek, Michigan. One "BB" Moore boiler feed pump.

Vermont Farm Machine Co., Bellows Falls, Vermont. One 650 pound United States Separator.

The DeLaval Separator Co., 74 Courtland St., New York. One 650 pound Alpha Separator.

The Empire Cream Separator Co., Bloomfield, N. J. One 650 pound Empire Separator.

The Omega Separator Co., Lansing, Michigan. One 650 pound Omega Separator.

The Sharpless Separator Co., West Chester, Pa. One 750 pound Sharpless separator.

The E. W. Ross Co., Springfield, Ohio. One 16-inch, self feed, Ross ensilage cutter.

Swift & Co., Chicago, Ill. 500 pounds meat meal.

Cyphers Incubator Co., Buffalo New York. One No. 2 incubator.

John W. Barwell, Waukegan, Illinois. One gallon Karbo Kresolate Dip.

Park Davis Co., Detroit, Michigan. 10 gallons Kreso Dip.

General Machine & Supply Co., Chicago, Illinois. One hand power sheep shearing machine.

Stark Bros., Louisiana, Mo. One dozen new apple trees for trial.

Prof. N. E. Nansen, Brookings, S. Dak. Small plants and cuttings of hardy ornamental plants.

Zenner Disinfectant Co., Detroit, Michigan. 5 gallons Zenoleum.

Dr. William Saunders, Ottawa, Ontario, Canada. Cuttings of hardy ornamental trees.

S. A. Bulford, Experimental Farm, Brandon, Man. Hardy ornamental plants.

W. Atlee Burpee & Co., Philadelphia, Penn. Flower and vegetable seeds.

EXCHANGE LIST.

Agricultural Eptiomist; Spencer, Indiana.
American Fancier, Johnstown, New York.
American Fertilizer, Philadelphia, Pennsylvania.
American Hay, Flour & Feed Journal, Milwaukee, Wisconsin.
American Poultry Advocate, Syracuse, New York.
American Poultry Journal, Chicago, Illinois.
Beet Sugar Gazette, Chicago, Illinois.
Big Timber Pioneer, Big Timber, Montana.
Billings Times, Billings, Montana.
Bozeman Chronicle, Bozeman, Montana.
Butte Inter-Mountain, Butte, Montana.
Chicago Dairy Drovers' Journal, Chicago, Illinois.
Chicago Dairy Produce, Chicago, Illinois.
Chicago Live Stock World, Chicago, Illinois.
Chicago Markets, Chicago, Illinois.
Chinook Opinion, Chinook, Montana.
Coleman's Rural World, St. Louis, Missouri.
Daily Independent, Helena, Montana.
Dairy Record, St. Paul, Minnesota.
Deseret Farmer, Provo, Utah.
Dillon Examiner, Dillon, Montana.
Dillon Tribune, Dillon, Montana.
Farmers' Advocate, Winnipeg, Manitoba.
Farmer & Breeder, Sioux City, Iowa.
Farmers' Guide, Huntington, Indiana.
Farmers' Review, Chicago, Illinois.
Farm, Field & Fireside, Chicago, Illinois.
Farm Home, Springfield, Illinois.
Farm Journal, Philadelphia, Pennsylvania.
Farm Progress, St. Louis, Mo.
Farm News, Springfield, Ohio.
Farm, Stock & Home, Minneapolis, Minnesota.
Farm Poultry, Boston, Mass.
Feather, Washington, D. C.
Fruit Grower, St. Louis, Mo.
Furrow, Moline, Illinois.
Gallatin County Republican-Courier, Bozeman Montana.

Gallatin Farmer & Stockman, Belgrade, Montana.
Gem State Rural, Caldwell, Idaho.
Gleanings in Bee Culture, Medina, Ohio.
Glendive Independent, Glendive, Montana.
Great Falls Weekly Tribune, Great Falls, Montana.
Home & Farm, Louisville, Ky.
Horticultural Visitor, Kinmundy, Ill.
Hospodar, Omaha, Neb.
Independent, Miles City, Montana.
Irrigation Age, Chicago, Illinois.
Jersey Bulletin, Indianapolis, Indiana.
Kansas Farmer, Topeka, Kansas.
Kimball's Dairy Farmer, Waterloo, Iowa.
Livingston Post, Livingston, Montana.
Madison County Monitor, Twin Bridges, Montana.
Madisonian, Virginia City, Montana.
Milk River Valley News, Harlem, Montana.
Montana Stockman & Farmer, Helena, Montana.
National Farmer & Stockgrower, St. Louis, Mo.
National Farmer, Winona, Minn.
Nebraska Farmer, Omaha, Neb.
Northwest Poultry Journal, Salem, Oregon.
Northwest Tribune, Stevensville, Montana.
Orange Judd Farmer, Chicago, Illinois.
Oregon Agriculturist, Portland, Ore.
Pacific Coast Fancier's Monthly, San Jose, Cal.
Pacific Dairy Review, San Francisco, Cal.
Pacific Fruit World, Los Angeles, Cal.
Pacific Poultryman, Tacoma, Washington.
Park, Cemetery and Landscape Gardening, Chicago, Illinois.
Plainsman, Plains, Montana.
Poultry Herald, St. Paul, Minn.
Poultry Husbandry, Waterville, New York.
Poultry Success, Springfield, Ohio.
Prairie Farmer, Chicago, Illinois.
Rocky Mountain Husbandman, Great Falls, Montana.
Republic, St. Louis, Mo.
Rural New Yorker, New York.
Semi-Weekly Missoulian, Missoula, Montana.

Southern Farm Magazine, Baltimore, Md.
Southwestern Farmer & Breeder, North Fort Worth, Texas.
Stockgrowers' Journal, Miles City, Mont.
Successful Farming, Des Moines, Iowa.
Successful Poultry Journal, Chicago, Illinois.
The Sugar Beet, Philadelphia, Pa.
Wallace's Farmer, Des Moines, Iowa.
Western News, Hamilton, Montana.
Western News, Libby, Montana.
Western Swine Breeder, Lincoln, Neb.
World, Vancouver, British Columbia.
Yellowstone News, Mondak, Montana.
Reliable Poultry Journal, Quincy, Illinois.

ANIMAL INDUSTRY DEPARTMENT.

F. B. LINFIELD.

During the past year the Animal Industry Department carried on an number of experiments with steers, sheep and hogs. The results of these tests were reported in Bulletins Nos. 57, 58 and 59 and these have been distributed. During the coming year it is planned to take up some experiments in feeding milk cows and in the raising of calves, both for the dairy and for beef. As soon as the pasture can be properly divided some tests will be made of the value of permanent pasture under irrigation.

Considerable work yet needs to be done to get the pastures and yards in shape for the most satisfactory work with our live stock, and these things take time as well as funds.

POULTRY DIVISION.

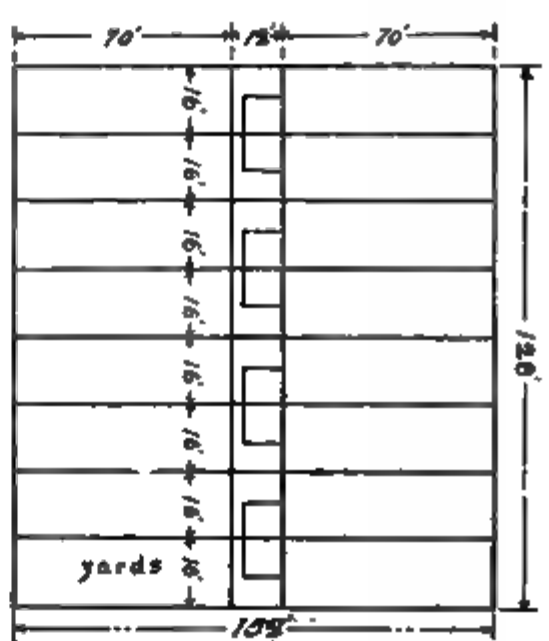
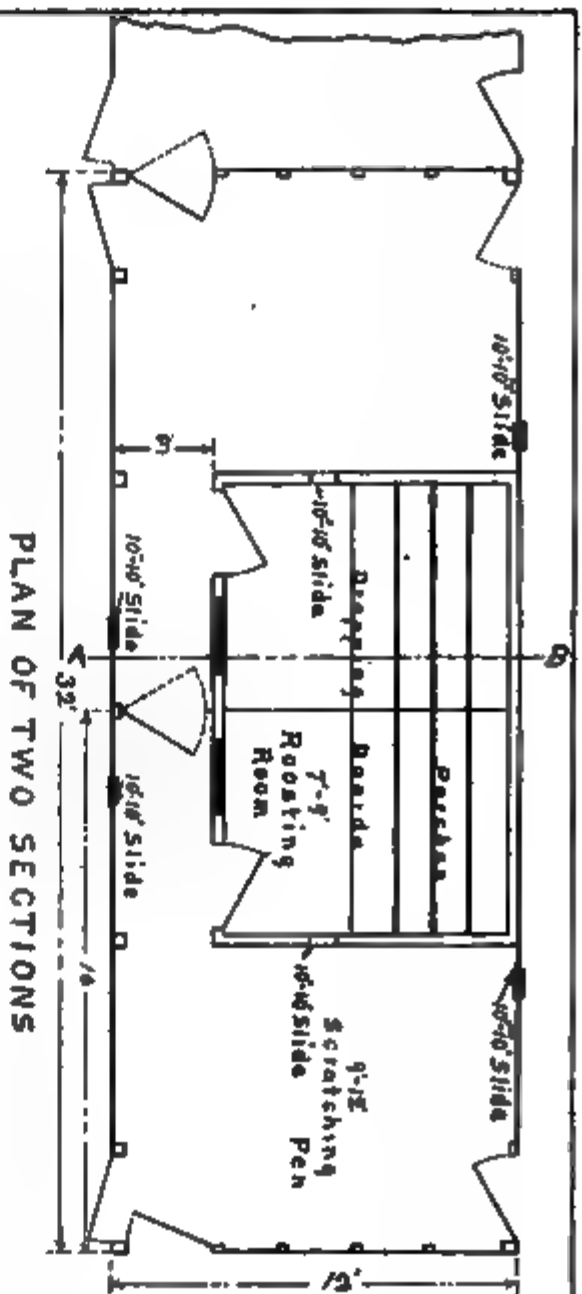
In the poultry division, Mr. James Dryden severed his connection with the Station in the spring of 1905 and later, Mr. J. R. Scott of Dillon, was engaged to take charge of the plant and has rendered very able service. It has been a year of expansion and building in this division. During the year a new poultry house has been built large enough to accommodate about 200 laying hens, which gives three times the previous capacity of the poultry plant. A woven wire fence has been built around the ground set apart for the poultry work, enclosing about 2 1-7 acres.

The number of breeds of fowls kept were increased during the year and we now have Single Comb Brown Leghorns, Rose Comb Brown Leghorns, Single Comb White Leghorns, White Wyandottes Barred Plymouth Rocks, and White Brahmas. This gives us representative breeds of the three main types of fowls.

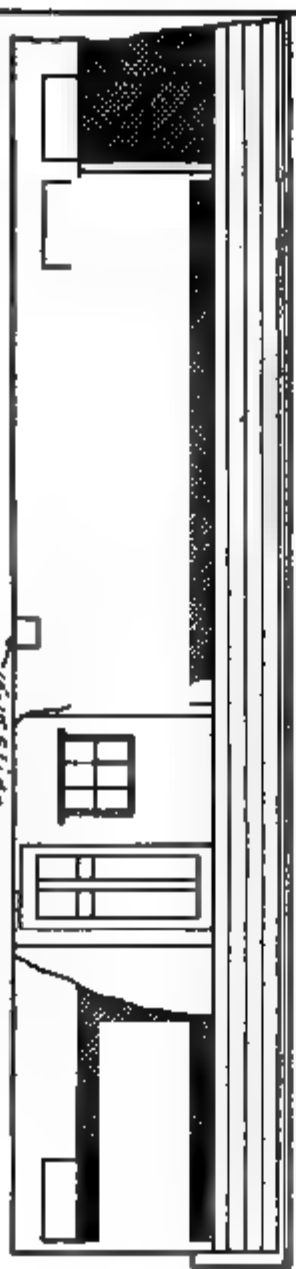
During the year we have raised a large number of fowls to replace the old stock on hand and to fill up the space provided in the new house.

The trap nests were run throughout the year in several pens and we now have yearly egg records for a large number of the birds.

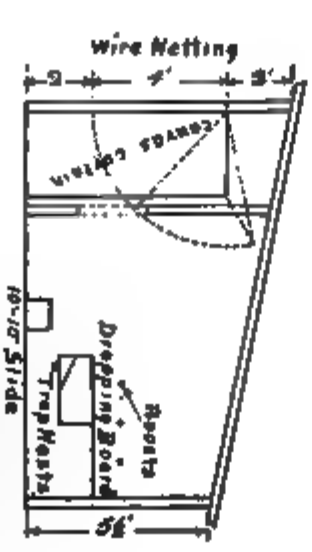
NEW POULTRY BUILDING



GROUND PLAN
YARDS and BUILDING



FRONT ELEVATION OF TWO SECTIONS
NEW POULTRY HOUSE. MONTANA AGRICULTURAL COLLEGE



CROSS SECTION THROUGH A.B.
NEW POULTRY HOUSE. MONTANA AGRICULTURAL COLLEGE

These egg records will be used as a basis for breeding up and improving the flock, the increase stock to be added to the flock we will raise from the large layers.

In a pen of 8 Barred Plymouth Rocks, the egg record ranged from 61 to 105 eggs for the year. The average egg record was 80.

A pen of four Single Combed White Leghorns produced from 107 eggs to 133 and averaged 126 for the year.

A pen of three Rose Combed Brown Leghorns produced from 113 eggs to 147 eggs and averaged 133 eggs for the year.

We had three pens of Single Comb Brown Leghorns and for two of these the trap nests were used. In the first pen there were 24 birds. They laid from 16 to 156 eggs each and averaged 94 for the year. The second pen contained 25 fowls. The egg productions ranged from 42 to 140 eggs for the year and averaged 105. The third pen was kept in a small colony house, and contained 30 Single Comb Brown Leghorns for 8 months of the year and after that but 15 birds. The total eggs produced were 3309, which at an average of 20 birds for the year would mean an average return of 165 eggs for the 12 months from each bird. These birds had quite a free range but were housed in a small cheap house 8x14 feet with a small roosting pen 4x7 with a drop curtain in front. These fowls made the best record of any on the place and the house that sheltered them cost not more than \$25.00 to \$30.00. At an average price of 2 cents a piece for the eggs (24c a dozen) the pen returned \$66.18 or over \$3.00 each for the average of 20 birds for the year.

NEW POULTRY BUILDING.

Plates 1 and 2 present a front view and plans of the new poultry building. This house is built with an open curtain front, scratching shed and a roosting room that may be closed up snugly in cold weather. The outside walls at the back and ends are boarded with rough lumber on the studding, then tarred paper and on this rustic siding. Two roosting pens are built together and are divided by a single board partition. The outside walls of the roosting pen have tar paper and shiplap on each side of the studding. The roof of the roosting pen is first tar paper on the rafters and then sealed with shiplap. This gives quite a warm pen and the birds kept in good health even in the coldest weather. The drawings give sufficient data to fully explain the other details of the building.

BIOLOGICAL DEPARMENT

R. A COOLEY, *Entomologist.*

Under executive instruction, on July 1, 1905, the Entomological Department was extended and made to embrace experiment station work in botany also, the new department being known as the Biological Department. In adjusting ourselves to the change it became necessary to make extensive rearrangements in the room previously occupied by the Entomological and Botanical Departments. As these changes were going on, it seemed advisable also to rearrange the office work in entomology, placing it on a more systematic basis. Confronted by these duties, it was found inadequate to attempt extensive field investigations during the summer months. Accordingly, much time was spent in the office and supervision of the changes underway and the construction of an insectary.

With our new facilities, we feel that our efforts may be much more effective in the future. It will now be possible to make life-history studies, which were quite out of the question before the erection of the insectary. However, we must again call attention to the fact that the rooms we now occupy for our College and Experiment Station work are inadequate and inappropriate for the work demanded of us by the state and provided for by federal funds. The only space we have available for general work, outside of the over-crowded office, is in the Zoological laboratory used by classes in zoology and physiology. In this same room, next year, it will be necessary not only to have two distinct kinds of laboratory work conducted, but in one of these lines it will be necessary to have the class separated into divisions.

INSECT COLLECTION.

Through collecting and exchange we are accumulating a large and valuable cabinet of insects of all orders. During the past year many additions have been made and the collections have been put

THE INSECTARY, MONTANA AGRICULTURAL COLLEGE
Used for the study of the life-histories of Insects.

in readily accessible form. We have recognized nearly 125 species of Orthoptera from Montana, and the collection of Coleoptera, including some secured from out of the state, now numbers about 1,500 species.. For the future usefulness of our work in entomology, it will be necessary to press forward with this branch until our collections represent at least a fair proportion of our Montana insects.

BOTANICAL COLLECTIONS

The herbarium, owned by both the College and the Experiment station, contains about 15,000 sheets of Montana species, about 5,000 from other parts of the United States, and 800 species from India.

Of Cryptogams, our herbarium now contains Cummings, Williams and Seymour's Lichenes Boreali Americani (250 specimens), Kenauld & Cardot's Musci Europaei (250 specimens), Collins, Holden, & Setchell's Phycotheca Boreali Americana (850), Seymour & Earle's Economic Fungi (500), Ellis & Everhart's Fungi Columbiani (2,200), and several hundred other specimens from Montana.

ENTOMOLOGICAL FEATURES OF THE YEAR

In more or less restricted localities grass-hoppers have been abundant and injurious. The Two-striped Locust (*Melanoplus bivittatus* Say.) has been excessively abundant in some places in the Yellowstone Valley. One somewhat neglected orchard was visited in which these grasshoppers almost covered the earth and clung to the trees in great numbers. Residents of the locality who were with me did not consider them to be abundant compared with other nearby localities. This species was also found in some places injuriously affecting sugar beets by eating out the tender growing centers of the plants, and alfalfa by biting off seed bearing stems in fields grown for seed. Other species abundant and complained of by farm owners are the Carolina Locust (*Dissostertia carollna* Linn.), the Lesser Migratory Locust (*Melanoplus atlanis* Riley), and the Red-legged Locust (*Melanoplus femur-rubrum*, De G.).

The Currant Maggot and the Gooseberry Fruit Worm have been prominent by reason of the number of inquiries that have been made regarding them. Cut worms were abundant in the early part

of the season in gardens, beet fields, and on lawns. A related species known popularly as the Cotton Boll Worm or the Corn Worm (*Heliothis armiger* Hubn.) became injurious to sweet corn in all parts of the state and it attacked field corn freely also in the few fields to be found in the Yellowstone Valley. In many fields of sweet corn only a small proportion of the ears escaped injury. Plant lice (*Aphididae*) of various species have continued to be very abundant. Prominent among these are the "Grain Aphis" (*Nectarophora granaria* Kirby), the "Apple Leaf Aphis" (*Aphis pomi* De G.), "The Cabbage Aphis" (*Aphis brassicae* Linn.), "The Box-Elder Plant Louse" (*Chaitophorus negundensis* Thome.) and the "Elm Gall-louse" (*Schizoneura americana* Riley).

In the western part of the state the Oyster-shell Bark-louse finds conditions so favorable to its existence that it multiplies rapidly and where present is looked upon as a serious pest. It has been detected in a few new locations during the past year. We have received numerous complaints of the Spotted Blister Beetle (*Epicauta maculata* Say), particularly as a pest of potatoes and sugar beets.

PRELIMINARY REPORT ON SUGAR BEET INSECT PESTS

That Montana will successfully produce sugar beets on a commercial scale seems to be an assured fact. A sugar beet factory, will be erected in Billings in season to care for the beet crop of that vicinity for the season of 1906, and a number of other factories will doubtless soon be established. The list of insect pests attacking sugar beets in the United States is rather a long one and it must not be expected that Montana will be favored with less than her share. It seemed desirable at this time to present a preliminary report on the insects that will or may be encountered by our farmers as they take up this industry which to them will be new. Accordingly the Entomologist made a short tour through the section about Billings in August 1905, for the purpose of detecting as many as possible of the insects that may be expected to be more or less serious as pests of the sugar beet. Only a very few days were spent in that part of the state and we are surprised to find so many of the pests of this class that have been reported from other parts of the United States.

THE LARGER SUGAR BEET LEAF BEETLE

Monoxia puncticollis Say.

This insect was found in a small field of sugar beets west of Billings. The beetles are gregarious and their brownish grey eggs are deposited unusually on the under side of the leaves. The princi-



c d b a

Fig 1. *Monoxia puncticollis*: a, female beetle; b, eggs; c, larva, dorsal view; d, larva, lateral view; O, claw of male; O, claw of female—all much enlarged, male and female claws more enlarged (Chittenden's illustration, Division of Entomology) U. S. Department of Agriculture.

pal injury is done by the larvae hatching from these eggs although the beetles were taken eating also. It feeds on a number of native wild plants which occur in Montana. According to Prof. Gillette it is double brooded. The larva measures one third of an inch in length, is dark olive brown in color with pale yellow spots or tubercles which are covered with fine hair.

This is a western species perfectly at home in the eastern part of Montana and it is probable that wherever its native food plants are destroyed in plowing up fields for sugar beets the insects will be more or less injurious on sugar beets. It has not yet been demonstrated whether this species will become a particular pest of sugar beets leaving its old food plants as did the Colorado potato beetle years ago.

PALE STRIPED FLEA-BEETLE

Systema blanda Mels.

This species has long been known as an enemy of beets and more recently has gained notoriety as a sugar beet pest. It attacks the plants while quite young, often injuring large areas by preventing the young plants from getting a start. They have been very injurious in Colorado. Among the many species of flea beetles this is one of the most common and most destructive. It measures about

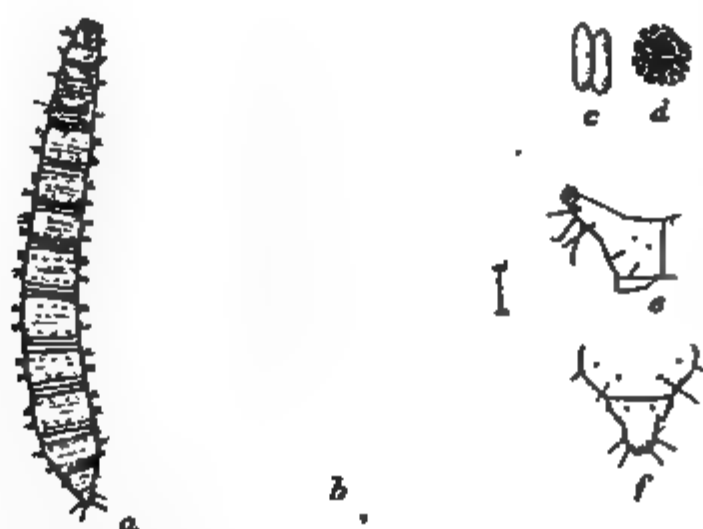


Fig. 2. *Systema blanda*: a, larva; b, Beetle; c, eggs; d, sculpture of eggs; e, anal segment, from side; f, same from above— a-d, six times natural size; e, f, much enlarged (Chittenden's illustration, Division of Entomology, U. S. Dept of Agriculture.)

an eighth of an inch in length and has striped wing covers. It attacks a long list of other plants besides beets, corn and potatoes being among its favorites.

The beetle hibernates in the adult state, appearing in the spring upon the plants just as they leave the ground. The slender whitish larvae feed on the roots of various plants.

THE BANDED FLEA-BEETLE

Systema taeniata Say.

The pale striped flea beetle has not yet been taken by the writer in Montana though it probably occurs here in great numbers

Fig. 3. *Systema taeniata*, dark variety—about 6 times natural size (Chittenden's illustration, Division of Entomology, U. S. Department of Agriculture).

in the eastern portion of the state. The Banded Flea-Beetle is known from notes in this office to be a common species in Montana. It frequently attacks the sugar beet. Its habits and method of work are similar to the preceeding species.

THE WESTERN CABBAGE FLEA-BEETLE

Phyllotreta pusilla Horn.

This is another common western species which is very liable to appear in the fields around Billings. It has been very common in

Fig. 4. *Phyllotreta pusilla*—much enlarged (after Riley, division of Entomology, U. S. Dept. of Agriculture).

parts of Colorado. It is particularly injurious to turnips and cab-

bages. We have received numerous complaints of flea beetles on these crops in the Yellowstone Valley which we believe to be attributable to this species although no specimens have been received. Like the other flea beetles its injuries are most apparent in the spring of the year when large numbers of the adults appear in the fields destroying the young plants.

THE SPINACH CARRION BEETLE

Silpha bituberosa Lec.

Unlike the preceeding species *S. bituberosa* is a very common Montana species. It may often be seen in the spring of the year running about on the surface of the ground. While the preceeding species is an introduction from Europe this is native and seems to be particularly abundant in the Northwest and in British America. At times they occur almost in swarms.

The beetle measures nearly half an inch, dull black in color,

Fig. 5. *Silpha bituberosa*: adult—much enlarged
(Chittenden Division Entomology, U. S. Department
of Agriculture.)

and has two prominent elevated lines, one on each side on the wing covers, which end abruptly two thirds of the way from the anterior end of the wings.

From the fact that *S. opoca* has not been taken in this state and that *S. bituberosa* has been found to be very common, it seems probable that injuries to the leaves of sugar beets is done by the latter species.

THE BEET CARRION BEETLE

Silpha opaca Linn.

We have received a number of complaints accompanied by specimens which were attributable to either this or a similar species of beetle. We have not taken *S. opaca* in Montana and our efforts to feed these larvae in confinement in order to secure adults have not been successful owing probably to lack of suitable conveniences. The larvae are black shining objects in general appearance resembling sow bugs. They feed at night or morning and evening and drop from the leaves and disappear suddenly as one approaches them. This species has long been known as an enemy of sugar beets and though others in the same group attack beets this is probably responsible for more damage than any other. A considerable amount of damage has been done by this or similar species on the Experiment Station farm. These beetles are remarkable for the fact that they are exceptions to the characteristic habits of the family. The great majority of the species feed in decaying and putrid matter.

THE SPOTTED BLISTER BEETLE

Epicauta maculata Say.

During the past four years we have received many complaints of the spotted blister beetle as an enemy to potatoes, beets, and various other plants. Among our farmers it is popularly called the long potato beetle. During visits to various sections in the Yellow-



Fig 6. *Epicauta maculata*—nearly three times natural size (Chittenden Division of Entomology, U. S. Department of Agriculture).

stone Valley we have almost invariably found this species to be

abundant. The early stages of these beetles make an interesting study. Their habits and development are unlike those of most beetles. Some species of this family, Meloidae, have been found to be of some benefit as destroyers of eggs of grass hoppers and it is very probable that *E. maculata* in the larvale state feeds on the eggs of the common grasshoppers of the regions it occupies. Two years ago at the time grasshoppers were so very abundant in the valley of the Yellowstone, we received an unusual number of complaints of this beetle as a destroyer of the tops of potatoes. It seemed probable that the usual numbers of the beetle had been produced as a direct result of the abundance of food in the form of grasshopper eggs. We were, therefore, at a loss to know what to advise with reference to the treatment for this beetle. If this beetle is a natural and formidable enemy of grasshoppers, it would seem to be a mistake to destroy them. It is evident, therefore, that more information regarding the life history of this species should be obtained.

NUTTALL'S BLISTER BEETLE

Cantharis nuttalli Say.

Nuttall's Blister Beetle is a very common and conspicuous species in Montana. Its colors are bright, metallic blue, though

Fig. 7. *Cantharis nuttalli*: female beetle, one-third larger than natural size (Chittenden's illustration, Division of Entomology, U. S. Department of Agri.).

at times individuals have a purplish, coppery appearance. They are often found feeding gregariously, sometimes in great numbers

THE SUGAR BEET WEBWORM.

Loxostege sticticalis Linn.

This species has been introduced from abroad and is gradually widening its range. The moth with fully expanded wings measures a little less than an inch from tip to tip and is of a purplish brown color with darker and paler bands as shown in the accompanying figure. The old home of this insect appears to be northern Asia

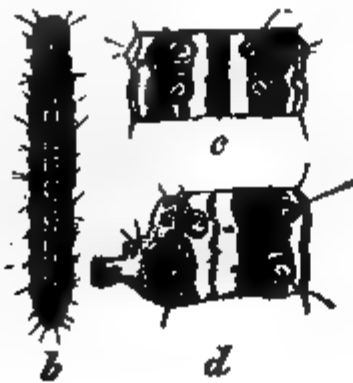


Fig. 8. *Loxostege sticticalis*: a, moth, twice natural size; b, larva, less enlarged; c, upper surface of first proleg of larva; d, side view of same, c, d, more enlarged (Chittenden, Division of Entomology, U. S. Department of Agriculture).

and Europe and it is likely that it was introduced from the Orient on the Pacific Coast. From there it has been slowly spreading eastward.

In a wild state in this country it feeds on pigweed (*Amaranthus*) and lambsquarter (*Chenopodium*) and in Europe it feeds of a species of *Artemisia*. This species, in a few instances, has been very destructive to sugar beets.

THE BEET ARMY WORM

Caradrina exigua Hbn.

The beet army worm is perhaps the insect most feared by growers of beets in the west. It is an imported species having come to this country by way of the Pacific coast and is now migrating eastward. It has in a few instances been very destructive to sugar beets and a few other plants and is to be looked upon as a very serious pest. It has not yet been detected in Montana. Allowing for our cooler climate it may be expected if at all in this state in

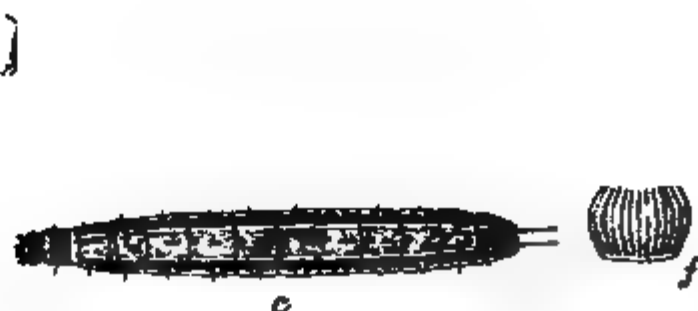


Fig. 10. *Caradrina exigua*: a, moth; b, larva, lateral view; c, larva, dorsal view; d, head of larva; e egg, viewed from above; f, egg, from side-all enlarged (after Chittenden, Division of Entomology, U. S. Department of Agriculture).

the latter part of June or early in July. A second brood comes in the late autumn.

The larva resembles a cutworm but is rather more slender than most cutworms. The head is small and the body is greenish as shown in the figure. Its food plants are fairly numerous, including wild grasses, planting, corn, potatoes, onions, peas, lambsquarter, pigweed, and saltbush. The wings of the moth are mottled gray and expand less than an inch and a half.

THE GARDEN WEBWORM

Loxostege similalis Gn

Like the sugar beet webworm this species feeds on pigweed in a wild state but unlike that species is a native American insect. It is smaller than the sugar beet species as shown in the figures. It feeds on a large number of plants but is particularly injurious to

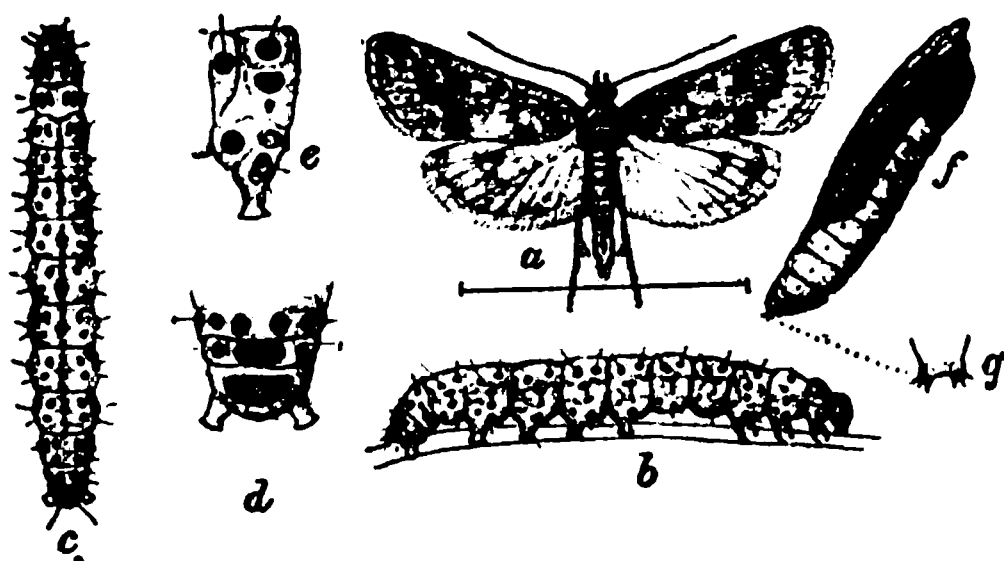


Fig. 9. *Loxostege similalis*: a, male moth; b, larva, lateral view; c, larva, dorsal view; d, anal segment; e, abdominal segment, lateral view; f, pupa; g, creamaster—a, b, c, f, somewhat enlarged; d, d, g, more enlarged (re-engraved after Riley, except c, (Chittenden, Division of Entomology. U. S. Department of Agriculture).

corn and cotton where these plants occur, vegetables, cereals and grasses making up its less preferred diet. This insect has not yet been detected in Montana and while it may do injury here it is thought that we are out of the zone in which it is injurious.

THE VAREGATED CUT-WORM

Peridroma margaritosa Haw.

Of all the various cut worms this species is perhaps the most destructive. It occurs throughout Europe and the United States. Its well known habit which it follows in common with many other cut worms of cutting off plants at or just below the surface of the ground renders it a very destructive species. There can be little doubt but that more or less damage will be done by this insect in the sugar beet fields of Montana.



Fig. 11. *Peridroma margaritosa*: a, moth; b, normal form of larva, lateral view; c, same in curved position; d, dark form, dorsal view; e, egg from side; f, egg mass on twig (after Howard, Division of Entomology, U. S. Department of Agriculture).

The full grown cut worm measures one and three-fourths inches. It is dull brown in general color mottled with gray and smokey black. A row of four to six yellow rounded spots half way between the dorsal and lateral line is characteristic of this caterpillar. We have been unable to bring to maturity any of the cut worms from the eastern end of the state. Among those that have been reared from Gallatin County we have not yet taken this species. It may be confidently stated, however, that it is here and that it will continue to injure various crops particularly those in the vegetable gardens.

THE WESTERN ARMY CUT WORM

Chorizagrotis agrestes Grote.

This species has become notorious throughout the United States for a remarkable raid upon crops in the Bitter Root valley.

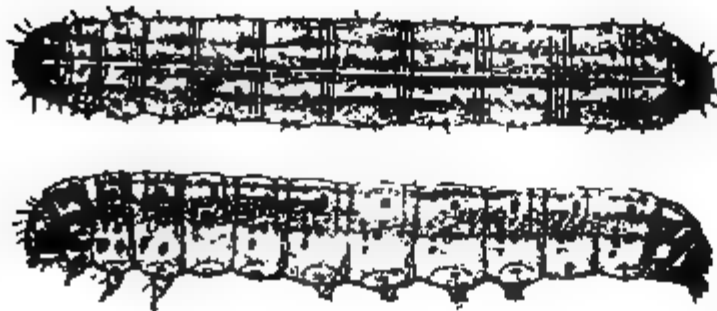


Fig. 12. *Chorizagrotis agrestis*: moth above; larva, dorsal view, in center; larva, ventral view, below—some-what enlarged (Chittenden, Division of Entomology, U. S. Department of Agriculture).

Besides attacking beets it feeds voraciously on a large number of farm and garden plants. The species is widely distributed in the West and may cause damage to sugar beets.

THE GREASY CUT-WORM.

Agrotis ypsilon Rott.

This cutworm is commonly found in beet fields according to reports of various writers. It is one of the most abundant and injurious of the insects of this kind. In size it resembles the variegated species in the larval state. It is of a dull dirty brown as in various cut worms but has the ventral surface paler and tinged with green. The entire surface has a glistening or greasy appearance.



Fig. 13. *Agrotis ypsilon*, a beet cutworm: a, larva, b. head of same; c, adult—somewhat enlarged (from Howard, Division of Entomology, U. S. Department of Agriculture).

Its habit of cutting off plants is pronounced.

With the two-striped locust a few other species were feeding in abundance. The Red-Legged Locust (*Melanoplus femur-rubrum* De G.) was among these species and is a common grasshopper in the eastern part of Montana. In some spots also the black-winged locust (*Dissosticra carolina* Linn.) was found in considerable numbers scattered throughout the beet fields. It is a strong flier and penetrates much farther into fields from the native vegetation than do the two species above mentioned.

THE TARNISHED BUG PLANT

(*Lygus pratensis* Linn.)

Of all the true bugs occurring in Montana this is, perhaps, the most abundant. It abounds on all native vegetation and is often reported injurious in the spring of the year. It prefers the young tender parts of plants, and by feeding upon them causes them to wilt or become dwarfed. The adult insect is a little over one-

Fig. 14. *Lygus pratensis*: adult bug at left; last stage of nymph at right—nearly four times natural size (Chittenden, Division of Entomology, U. S. Department of Agriculture.)

fourth of an inch in length and is grayish brown, marked in yellow. A few streaks of red occur on the thorax. It will be very surprising if this species does not occasion some anxiety, if not loss, to the owners of sugar beet fields.

THE FALSE CINCH BUG

(*Nysius angustatus* Uhl.)

This widely distributed bug frequently attacks many cultivated crops and weeds. At any time it causes more or less expensive loss by its raids upon cultivated plants. We have received a number

Fig. 15. *Nysius angustatus*: a, part of small leaf of potato, showing punctures of the bug; b, last stage of nymph; c, adult -a, natural size; b, c, much enlarged (After Riley, Division of Entomology, U. S. Department of Agriculture).

of complaints of what was supposed to be the true Chinch bug of states to the east of us, which were all traced to this bogus chinch bug. Its odor and size certainly remind one of that destructive enemy of grains.

THE WHITE LINED MORNING SPH INX

(Deilephila lineata Fab.)

During the past season this species became prominent in Montana on account of its great abundance. It feeds naturally on a great variety of wild growing plants. In the vicinity of Billings it was very abundant and was reported as feeding on both alfalfa



Fig. 16. *Deilephila lineata*. a, moth; b, pale larva, c, dark form of larva; d, pupa—all natural size (Chittenden, Division of Entomology, U. S. Department of Agriculture).

and sugar beets. Its abundance in the summer of 1905 was unprecedented in the writer's experience. Standing in one position thirteen caterpillars of various sizes were seen on the weeds in a neglected garden spot.

THE TWO STRIPED LOCUST

(Melanoplus bivittatus Say.)

A number of species of grasshoppers were found in some fields of sugar beets in the Yellowstone valley. Among these the two-striped was the most abundant. In other localities, away from sugar beet fields, they were found in unusual numbers. One orchard

Fig. 17. *Melanoplus bivittatus*, natural size (after Riley).

near Park City had been greatly injured. It is the habit of these grasshoppers to feed from the young tender leaves growing from the center of the plant. They were most abundant in the edges of the field.

CHEMISTRY DEPARTMENT.

V. K. CHESNUT, *Chemist.*

Aside from the miscellaneous tests and analyses of minerals, coal, water, food stuffs and soils, and the accompanying correspondence which fall to the lot of every Station chemist and which, for proper execution, often require much time and thought, the work for the past year has been specifically directed into several well defined channels, which are briefly outlined herewith.

FORMALIN

Complaint having been made that grain treated in the regulation way with Formalin purchased in the Montana markets was not thereby freed from smut, samples were collected in various parts of the state for analysis. The results show that only one sample had the required 40 per cent. strength. In nearly every case, however, the strength was only 1 or 2 per cent. below standard, but in two samples the percentage of formalin in solution was so very low that treatment of grain with them would be nearly useless. The number of samples analyzed was small, but the work is to be continued next year.

FOOD CONTROL

During the last session of the state legislature, at the request of some of the prominent grocers and horticulturists of the state, and in co-operation with the State Veterinarian and the State Board of Health, together with Dr. A. D. McDonald, representing Flathead county in the house of representatives, a bill was framed with the view to the regulation of the sale of such food-products in the state as were not already included in the milk and meat inspection laws. The bill made adequate regulations to protect the people and the dealers from unscrupulous wholesale merchants and manufacturers, who, owing to the stringent laws in other states

and the absence of food laws here, have made Montana the dumping ground for all kinds of adulterated and low grade products, preserved with deleterious substances to cover up the bad odors generated by incipient decay and to kill the foul bacteria which cause these odors. This bill passed both the house and the senate, but was recalled and defeated in the senate. The bill was framed especially to include adulterated vinegar, flour, honey and such products as are now being manufactured in the state, and as the commercial success of these factories very greatly concern the agriculturist as well as all the other people in general, it was planned this year to make a chemical investigation of some of these food stuffs. A beginning has already been made with the meats and vinegars but sufficient data has not yet accumulated for a bulletin on the subject.

VINEGARS

Of eighteen samples subjected to the most critical examination, three were sold for straight acid vinegar, one for "tarragon," two for malt, three for white wine, and nine for pure cider vinegar. Of these the tarragon, the two malts and four samples of cider vinegars would pass in most states as legal; the remainder would be counted as spirit, acid or wood vinegars and would be condemned as illegal. It is worthy of note that two of the pure cider vinegars were the products of home industry, having been manufactured in the Bitter Root valley. Equally good vinegar is undoubtedly made in other parts of the state but no samples could be obtained in the markets where they were called for.

It will thus be seen that over 50 per cent of the samples of cider vinegar analyzed were adulterated and it is further evident that, if it is found that the high standard of the Montana products is maintained, it would be wise, so far as the supply exists, for the people of the state to demand home made vinegars in preference to those from other states, especially since the home product is of good flavor. They would thus be favoring a manufacturing industry, which, in time would be more than sufficient to supply the local markets, not only for table vinegar but also for pickling vinegar, which would in turn develop the cultivation of cucumbers and favor a new pickling industry. Pure cider vinegar at 50c. per

gallon would soon drive out the inferior substitutes and acid vinegars for which the same price is usually demanded in the local markets.

MEATS

A great deal of study has recently been made by the Bureau of Chemistry of the U. S. Department of Agriculture with regard to the effect of borax upon the general health and it has been shown by others that borax or boracic acid is not uncommonly used as a preservative in sausage and other sliced or chipped meats and occasionally in canned meats. Investigation shows that borax is rather commonly found in the canned meats sold in the Montana markets. Sixty-three samples were purchased from representative dealers in several parts of the state and examined chiefly for borax. Only six of the samples were found to be free from borax, but in nineteen the amount present was less than one grain per pound, an amount which might possibly have been introduced unintentionally. Seventeen samples of meat contained from one to three grains of borax per pound, ten contained three to six grains, five about ten grains, two about fifteen grains, one thirty-eight grains and one over one hundred grains per pound.

Most of these samples were canned meats, but a few were dried or in the form of sausage. The one containing the largest amount of borax being a finely shredded kind of cod fish. It is true that a considerable quantity of this large amount would be dissolved out from the fish in the soaking which it gets before it is cooked, but some of it would remain, and there is always the fear either that the meat treated with borax has united chemically with the borax to produce an indigestible compound or that, in the first place, before the borax was added, the meat had undergone decomposition and that, parallel with this development, poisonous ptomaines had been generated.

It is certainly unnecessary to add preservatives to untainted meat or to meats not suspected of being contaminated with contagious disease germs. To the chemist, preservatives are always suggestive of slovenly methods of manufacture; to the pharmacologist preservatives, like borax, are objectionable on account of their physiological effects.

The Bureau of Chemistry of the Department of Agriculture has, by an elaborate series of experiments, shown conclusively that "both boric acid and borax, when continuously administered in small doses for a long period, or when given in large quantities for a short period, create disturbances of appetite, of digestion and of health." It is often necessary to use canned meat for a considerable period of time, but, wherever possible, and especially in the case of invalids, fresh meat, a home product, should be substituted. If that is impossible, such brands should be selected as fully comply with some acceptable food law. For the good of the agriculture it is certainly to be hoped that one or more packing houses will soon be erected in the state. The fertilizer value of the bones, blood and other waste products would thus be retained for the enrichment of the soil.

SUGAR BEETS

The work of the year chronicles a rapidly increasing interest in sugar beet farming. The Billings sugar factory is now well advanced in the process of construction and factories are being considered in various parts of the state, especially in the Gallatin valley and the Bitter Root valley.

With the co-operation of the office of Plant Industry, and with Mr. M. Cordes, of Madison, Wis., who presented seeds to this department, three strains of beet seed were distributed throughout the state. The government seed was the Kleinwanzlebener variety and was grown at Fairfield, Wash., from mother beets of high sugar content and purity co-efficient. The seed presented by Mr. Cordes was of the Aderstedt and Mangold varieties, both of which are high grades of seed, imported from Germany. Over 150 pounds was distributed but only 28 samples of beets grown therefrom were presented for analysis. The average of the eight samples of Aderstedt beets gave a yield of 15.8 tons per acre, with 15.1 per cent sugar and 83.2 per cent purity. The average from the Morrison grown Kleinswanzlebener seed gave a yield of 16 tons per acre, with 15.2 per cent sugar and 83.1 per cent purity co-efficient.

The richest lot of sugar beets grown from these seeds was grown by Mr. Isaac Eddy, of Lothrop, who obtained, in a black loamy soil, an estimated yield of 22 tons per acre, with 19.7 per

cent sugar and 92.4 per cent purity co-efficient. This was from the government seed.

These beets were all grown without the immediate supervision of skilled men, but analysis shows that the beets are a trifle superior to those raised under skilled supervision at Billings. The average of eighteen samples grown there, from another variety of seed, gave a yield of 15 tons per acre, with a sugar content of 14.1 and a purity co-efficient of 83.1 per cent.

The government seed will be tested again next year in comparison with several high grade seeds.

POISONOUS PLANTS

In co-operation with the Bureau of Plant Industry of the U. S. Department of Agriculture, the permanganate antidote tablets given out gratuitously by the department were distributed to various persons throughout the state. These are intended primarily to save animals, especially sheep, poisoned by larkspur or death camas. Excellent results are reported by stockmen who have recently used the tablets. The antidote is cheap, is easily administered, is good in cases of poisoning from several varieties of plants, and since it is a good antidote for some cases of poisoning in man, it should be found on the medicine shelf of every household.

LOCOED SHEEP

The experiment begun last year of treating thirty "locoed" sheep with vermifuges and trying to fatten them for the market was concluded this year with very gratifying results. This work was undertaken with the co-operation of the Bureau of Plant Industry U. S. Department of Agriculture and the results will be published by the U. S. Department of Agriculture, as well as by this Station. A general outline of the results has already been published by Director Linfield in Bulletin No. 59 of this Station.

METEOROLOGICAL DIVISION.

EDMUND BURKE, *Meteorologist.*

This Station is located in about latitude 45 degrees, 40 minutes, 51 seconds and longitude 111 degrees, 2 minutes, 36 seconds, at an elevation of 4900 feet, and is now equipped with the following apparatus: A maximum and minimum thermometer, a recording thermometer, a wet and dry bulb thermometer, four soil thermometers, 5 feet, 3 feet 1 foot and 3 inches respectively; a quadruple register, together with wind vane, anemometer, rain gauge and electric sunshine recorder, a barograph and a mercurial barometer.

The instrument shelter for thermometers is placed ten feet above the ground, in an open field containing clover and alfalfa, and near by is a rain gauge to check the one attached to the quadruple register. The wind vane and anemometer are on the south tower of the chemical and physical building, 58 feet above the ground. The rain gauge and electric sunshine recorder are on the roof and the quadruple register, barograph and mercurial barometer are in the north tower of the same building. The top of the cistern of the barometer is 38 feet above the ground and 4936 feet above sea level.

Until last May, the quadruple register records had not been transcribed, but since that time all data are recorded daily, and by the aid of the recording thermometer and quadruple register the day is calculated from midnight to midnight (mountain time,) instead of from six p. m. to six p. m. as is usually done.

In this report only a summary of temperature, precipitation, character of day and the prevailing wind direction will be given.

SUMMARY FOR 1904-1905.

Highest temperature, 91, August 24, 1905.

Lowest temperature, -33, February 11, 1905.

Greatest range for the year, 124.

Highest monthly mean, 64.29, August, 1905.

Lowest monthly mean, 16.8, February, 1905.

Highest daily mean, 75, August 24, 1905.
Lowest daily mean, -24.5, February 11, 1905.
Mean temperature for the year, 41.65.
Greatest total precipitation for one month, 3.23, May, 1905.
Least total precipitation for one month, .23, January, 1905.
Total rainfall, 15.36 inches.
Total snowfall, 49.2 inches.
First killing frost, September 18, 1905.
Last killing frost, May 12, 1905.
No. of clear days in the year, 96.
No. of cloudy days in the year, 39.
No. of partly cloudy days in the year, 230.
Days with .01 inch or more of precipitation, 88.

SUMMARY BY MONTHS FOR 1904-1905

Months and Years	Temperature		Mean Temperature	Precipitation	Snow Fall	Clear Days		Partly Cloudy Days		Cloudy Days		Days .01 of an in. or more precipitation	Direction of Prevalling Winds
	Highest	Lowest											
November, 1904	60	-16	39.13	.37	2.6	8	20	2	3	S.	E.		
December, 1904	59	-10	25.67	2.30	20.3	6	22	3	8	S.	W.		
January, 1905	48	-12	20.8	.23	2.3	6	18	7	3	S.	E.		
February, 1905	56	-33	16.8	.75	4.0	17	10	1	5	S.	E.		
March, 1905	60	-8	35.7	.77	5.4	7	20	4	8	S.	W.		
April, 1905	71	-18	40.4	.80	3.0	7	21	2	7	S.	E.		
May, 1905	71	-26	45.2	3.23	2.0	4	23	4	16	S.	E.		
June, 1905	78	-33	52.8	2.62	0	3	22	6	14	S.	W.		
July, 1905	88	-42	63.3	.74	0	11	20	0	8	S.	E.		
August, 1905	91	-34	64.3	1.21	0	6	25	0	5	S.	E.		
September, 1905	84	-30	57.2	1.48	3.0	12	16	2	2	S.	E.		
October, 1905	78	-8	38.6	1.13	6.6	9	14	8	9	S.	E.		

HORTICULTURAL DEPARTMENT.

R. W. FISHER, *Horticulturist.*

The work in this department has been along much the same lines as in previous years. Varieties of vegetables, small fruits, tree fruits and ornamental trees and shrubs have been tested to determine their adaptability to Montana conditions, together with cultural and variety tests of both fruits and vegetables.

THINNING FRUIT

In July, 1905, fruit was thinned from several commercial varieties of apples in the Bitter Root valley, in the orchards of Bass Brothers, near Stevensville, and in the orchard of Mr. Samuel Dinsmore, near Florence.

On account of insufficient water to properly irrigate these orchards late in the fall much of the fruit fell from the trees before it was properly matured, thus making it impossible to determine accurately the relative yields of commercial apples from thinned and unthinned trees.

Determinations were made of the cost of thinning the fruit, and it was intended to measure the fruit in the fall from trees from which the fruit was thinned and the check trees left unthinned in order to determine the profits, if any, that could be gained by thinning the fruit early in the year. At the time the fruit was thinned the apples were about $\frac{3}{4}$ of an inch in diameter and all probability of natural thinning by frosts or other causes was passed. The trees ranged in age from 8 to 15 years old, and with most varieties there was a very full crop; many trees producing more apples than the limbs could support when the fruit matured. In the orchard of Bass Brothers two varieties were thinned, the Duchess and Wealthy.

An average of 918 apples were thinned from each tree, or about 3-8 of the crop. The resulting crop at maturity indicated

that even a heavier thinning than this would have given better results, as the trees were overloaded when the apples were ready to harvest.

In this orchard it took, on an average, 15 minutes to thin the fruit from one Duchess tree. These trees were headed low, with the apples a little larger than the Wealthies. At this rate it would take about 3.4 days for one man to thin the fruit from trees on one acre, or approximately \$7.00 per acre. It took 22 minutes to thin the fruit on each Wealthy tree. The trees were larger, with a heavier crop and smaller apples, thus explaining the reason for more time than was spent thinning the Duchess. At this rate with trees 18x18 feet apart or 137 trees per acre it would take 4.8 days to thin the fruit on one acre of trees or \$9.60 per acre.

The trees in this orchard were closer together than is best, and if there were only 100 trees or less per acre less time would be necessary in thinning, and better results could be obtained.

Because of a shortage in irrigation water for the last irrigation, which caused many apples to fall from the trees before time to harvest them, together with a very heavy windstorm during the summer, which blew many unripe apples from the trees, both thinned and unthinned, it was impossible to get accurate and absolute data in regard to comparative values of fruit from the thinned and unthinned trees, as was planned at the beginning of the experiment.

The following letter from Mr. D. C. Bass, one of the oldest and most progressive fruit growers in the Bitter Root valley, indicates, however, the importance from a commercial standpoint of thinning:

Stevensville, Montana, Jan. 6, 1906.

Mr. R. W. Fisher, Bozeman, Montana,

Dear Sir: The experiment conducted by you was not a fair test, owing to the scarcity of water and a severe windstorm that blew nearly all the Duchess off.

The thinning of the Wealthy apples increased the size of the remaining apples to at least 1-3. * * * * * * *

Yours truly,

(Copy.)

D. C. Bass.

The successful fruit growers in Idaho, Washington and Oregon attribute their success largely to the methods of handling their crops—and thinning the fruit is not the least important of these operations.

In Montana there is a tendency for all apple trees to overbear, thus not only devitalizing the tree but resulting in a large crop of apples of inferior size, which are not marketable at profitable prices to the fruit growers. The results obtained in the orchard of Mr. Bass, while not absolutely definite for reasons above stated, indicate that thorough thinning will result in producing a much larger yield of marketable apples.

The results obtained in the orchard of Mr. Samuel Dinsmore, near Florence, superintended by Mrs. Steve Prayer, were quite similar to those in Bass Bros.' orchard. The results obtained in this orchard were as follows:

It took 9 minutes to thin the fruit on each McIntosh tree, or at the rate of one acre in two days when trees are planted 18x18 feet apart. Not all the trees of this variety were bearing a full crop, and none of them seemed to be overloaded and in need of thinning at the time we thinned, early in July. However, in the fall, when the fruit was mature, those trees that had been thinned heaviest bore the best crop—and the trees that apparently had but a few apples on in the spring bore a very full crop. There is danger in not thinning enough.

The Alexander trees were well loaded and it took 14 minutes to thin each tree, or at the rate of about 42 trees a day.

When I visited this orchard in September, at the time when the fruit was being harvested, I could see an appreciable gain in size and uniformity of fruit on trees that had been thinned. Because of the naturally large size of this variety, it may not demand as much thinning as smaller varieties, unless it be to protect the trees from breaking down under the heavy load of a full crop of Alexander apples. The Northern Spy and Wolf River showed but little if any difference as a result of thinning, due to the unevenness of the crop and conditions, before mentioned, which caused the fruits to fall badly before mature.

While the results of thinning were not as apparent in this orchard as in the orchard of Mr. Bass, yet from my own observations and that of Mr. Prayer, whose letter is given here, the thinning had

a very beneficial effect upon the size and uniformity of the apples:

Stevensville, Montana.

Mr. R. W. Fisher,

Dear Sir: In regard to the apples, it is a hard proposition to tell much about them accurately, as we had a windstorm that blew off many, but I am sure that there would have been quite a difference if we could have given them a square deal. I think that there would have been a gain of at least 1-3 in yield in favor of thinning, and, besides, thinning is a great help to the tree.

Yours truly,

Steve Prayer.

It is thus seen, that while the experiments in these orchards did not show definite results, yet the indications are that thinning the fruit on heavily loaded trees will result in a very material increase in marketable fruits.

The work of thinning will be continued another year, when we hope to get more accurate results.

DAIRY DEPARTMENT.

W. J. ELLIOTT, *Dairyman.*

Since the last report, the dairy industry of the state has developed at a remarkably rapid pace. Where two years ago there were some two or three creameries in the state, the spring of 1906 opens up with some 25 creameries ready for business. This is a very creditable showing, yet, when we consider that our home consumption of butter would keep some 100 creameries running all year round, we see that there is still room for considerable development. That many other localities are thinking of building is evidenced by the fact that calls are coming in constantly to the dairy department for talks on the organization and building of creameries.

With the new creameries that are starting, many are asking us to hold dairy meetings to help to get more of the farmers interested, and we feel that this direction is needed to help and maintain an industry that promises to fill a prominent place agriculturally in the state.

The bulletin which was gotten out last year has been distributed over the state and calls still continue to come in for it, so that we feel that it is fulfilling its mission.

In the last year's report mention was made of the fact that a herd had been purchased with a view to seeing just how much an ordinary herd of Montana cows would pay in the dairy business. At that time we had not had the herd for a complete year, so that a definite statement could not be made. At this time, however, we are able to give a complete yearly record, and have been gratified at the returns, which have proven clearly that there is money in the dairy business in Montana if it is properly managed.

We here submit a complete table of the total receipts from each of the cows. It must be borne in mind that these figures do not consider the value of the calf nor the manure. We have allowed these two items to off-set the care and labor account, so that

the difference between the two tables will give us the net profit from each animal. Table No. 1 gives the total income from each cow in the herd:—

TABLE 1. Milk and Butter Yield and Cash Returns From Each Cow.

Name	Days Milked	Days Dry	Pounds Milk	Pounds Butter Fat	Pounds Butter	Butter at 25c	Skim Milk at 15c per Cwt.	Total
Sallie	341	24	5860.6	250.3	292.0	\$73.00	\$ 8.70	\$ 81.70
Buttercup	365		6673.2	324.5	378.5	94.60	9.90	104.50
Veda	281	84	6391.8	261.9	307.2	76.80	9.45	86.25
Spike	325	40	5784.6	253.5	295.7	73.90	8.55	82.45
Dell	279	86	5096.8	247.7	288.9	72.20	7.50	79.70
Stub	287	86	6085.8	257.4	300.3	75.05	9.00	84.05
Celia	236	129	5705.2	229.0	267.1	66.70	8.55	75.25
Cherry ..	243	122	5076.4	235.6	274.8	68.70	7.50	76.20
Blackie	304	61	7268.6	288.5	336.5	84.10	10.80	94.90
Blue Beard	332	33	4873.7	213.0	248.5	62.10	7.20	69.30
Pied	302	63	6492.4	246.3	287.3	71.80	9.60	81.40
Jernie	228	137	4687.7	176.7	206.1	51.50	6.90	57.40
May	244	21	5865.8	219.5	256.0	64.00	8.20	72.20
Honey	365		5683.2	228.8	266.9	66.70	8.40	75.10
Mollie	268	97	8339.7	313.5	365.7	91.40	12.45	103.85
Average	291.6	78.6	5992.4	249.75	291.43	\$72.836	\$ 8.846	\$81.616

TABLE NO. 2. The Amount and Cost of the Feed For Each Cow.

Cows	Months fed in Barn	Cwt. of Hay Eaten per Month	At \$5.00 per Ton	Grain per Month	At \$1.00 per Cwt.	Months pastured	At \$1.00 per Month	Total Cost of Keep
Sallie	7	9.00	\$15.75	150	\$10.50	5	\$5.00	\$31.25
Buttercup	7	9.00	15.75	150	10.50	5	5.00	31.25
Veda	7	10.20	17.85	180	12.60	5	5.00	35.45
Spike	7	9.00	15.85	180	12.60	5	5.00	33.45
Dell	7	9.00	15.75	150	9.00	5	5.00	29.75
Stub	7	9.00	15.75	180	12.60	5	5.00	33.35
Celia	7	9.00	15.75	150	9.00	5	5.00	29.75
Cherry	7	9.60	16.80	180	12.60	5	5.00	34.40
Blackie	7	9.60	16.80	180	12.60	5	5.00	34.40
Blue Beard	7	9.00	15.75	150	9.00	5	5.00	29.75
Pied	7	9.00	15.75	180	12.60	5	5.00	33.35
Jennie	7	9.00	15.75	135	9.45	5	5.00	30.20
May	7	8.70	15.22	180	12.60	5	5.00	32.85
Honey	7	9.00	15.75	150	9.00	5	5.00	29.75
Mollie	7	10.50	18.60	210	14.70	5	5.00	37.80
Average	7	9.24	\$16.19	167	\$11.29	5	\$5.00	\$32.45

In order that we may see the comparative value and profit from each animal more clearly, we will give a table giving only the exact cost of feed per animal, the total value of the product sold and the net gain from each.

Table No. III. The Value of the Product and the net Profit on the Feed for Each Cow.

Name	Total Receipts	Cost of Keep	Gain	Name	Total Receipts	Cost of Keep	Gain
Sallie	\$ 81.70	\$31.25	\$50.45	Blackie	\$ 94.90	\$34.40	\$60.50
Buttercup	104.50	31.25	73.25	Bluebeard	69.30	29.75	39.55
Veda	86.25	35.45	50.80	Pied	81.40	33.35	48.05
Spike	82.45	33.45	49.00	Jonnie	57.40	30.20	27.20
Dell	79.70	29.75	49.95	May	72.70	32.85	39.85
Stub	84.05	33.35	50.70	Honey	75.10	29.75	45.35
Celia	75.25	29.75	45.50	Mollie	103.85	37.80	66.05
Cherry	76.20	34.40	41.80	Average	\$ 81.983	\$32.45	\$49.20

These tables present a number of very interesting facts, and one of them is that it is necessary to very carefully study the cows

that we have in the herd, and especially those that we purchase. We should never allow a cow to occupy a stall in a stable if we can get a cow that will produce more, for the same cost of keep. The first two cows listed in table No. 3 show a very great difference. It cost exactly the same to keep each of them, while one produced \$22.80 more than the other in clear gain.

The amount that an animal eats must also be considered. Take, for instance, the two cows, Buttercup and Mollie. The one produces within 65c. of the other, but it costs \$6.55 more to keep one than it does to keep the other, thus making a difference of \$7.20 in their net income.

Again, we should not only watch that we do not keep any unprofitable cows in the herd, but it will pay to watch the total production and the cost of keep. We should use the scales very frequently in the herd for both feed and milk. Again, if we will refer to table No. 1, we will see that there is a great difference in the length of time that the various cows in a herd are dry. The number of days range from 137 to 24 days. If this particular time were more carefully watched it would make a vast difference in our cows as profit makers.

At present an experiment is under way with the dairy herd, to ascertain the best ration of grain to feed dairy stock. As this experiment is not yet completed a report will be given later.

AGRONOMY DEPARTMENT.

ALFRED ATKINSON, *Agronomist.*

During the past year considerable of the effort of this department was directed toward getting the work organized and a system of plots established. Twenty-one acres of the most uniform land on the Experiment Station farm was laid off into upwards of four hundred plots, varying in size from one-fortieth to one-twentieth acre each. A system of carefully constructed permanent roads was installed so that the future work may now be pursued most expeditiously.

Several lines of work were started and will be followed by this department until safe conclusions are reached. The one claiming a large share of the attention is the variety test work designed to bring about the introduction into Montana of the very best strains of the different cereals, clovers, grasses, roots and tubers. Varieties of these crops are procured from all parts of the American and European countries and tested for a number of years under like conditions. After a sufficient number of tests to enable the very best to be chosen, the amount of these grains will be increased and distributed to growers over the state. They will also be used as the basis for further improvement by the methods of breeding and selection. Montana's climatic and soil conditions are very favorable for the growth of the cereals and there is no reason why many other states may not be attracted to us for their seed grain supply.

A series of fertility and rotation tests were begun with the idea of determining the very best crop systems, as well as accumulating local results that will point out to Montana farmers the wisdom of such methods. Some of the rotation being tested on two years' grain and two years' clover; two years' grain and two years' summerfallow; two years' grain, one years' inter-tilled crop and two years' leguminous crops, and a few others along similar lines.

In co-operation with the irrigation and chemical departments,

this department is carrying on a series of irrigation investigations. The object of this work is to determine the effect of varying quantities of water on the field and quality of the different crops. The crops included in the test on oats, wheat, sugar beets, clover and alfalfa. There are seven plots in the case of each crop and the amounts of water added are 36 inches, 30 inches, 24 inches, 18 inches, 12 inches, 6 inches and no water. While the work has not been pursued far enough to point to definite conclusions, yet the observations as to the effect on ripening, quality, etc., are very interesting.

Several lines of investigation with alfalfa were commenced. Fourteen different varieties, procured from various parts of this as well as other countries, were sown in plots under identical conditions, and their value of hay and seed production will be determined.

Two series, of nine plots each, were planted to find out if possible the best and most economical quantity of alfalfa seed to sow. Quantities ranging from four pounds up to thirty-six pounds per acre were sown and their values will be investigated for the purpose of seed and hay returns.

The question as to whether it is best to plant alfalfa with or without a nurse crop is one on which wide difference of opinion exists. In order to throw light on the subject, an experiment along this line was started and will be followed until safe conclusions are reached.

Outside of the area used for plot tests and pasture, 7625 acres of the Experiment Station farm were devoted to crop growing this year. This was divided as follows: In oats, 33.76 acres, with an average return of 94.7 bushels per acre; in field peas, 6.8 acres, with an average return of 42.2 bushels per acre; in hulless barley, 3.7 acres, with an average return of 51.8 bushels per acre; in spring wheat 6.32 acres, with an average return of 43 bushels per acre; in barley, 5.67 acres, with an average return of 52 bushels per acre, and in hay, 20 acres, with an average return of 3.85 tons per acre.

It is the intention to conduct the farm crops under a four year rotation system, two years in grain and two years in clover. On account of winter killing of clover this was interfered with the past season, but will be returned to as soon as possible.

THE VALUE OF A PEA CROP AS FERTILIZER.

A very forceful illustration of the value of peas as a soil improver was brought out in the area devoted to barley during the past season. A portion of the crop, 2.72 acres, was grown on land that had produced spring wheat the previous year and this had followed a barley crop. The yield from this land which had been cropped the two previous years to cereal grain was 35 bushels per acre. The remaining 2.95 acres had produced peas the year previous and on this land the yield of barley was 67.7 bushels per acre. This very marked increase in the yield was due wholly to the good effects of the pea crop, and points out the great value of including peas or some nitrogen gathering crop in the rotation.

IRRIGATION DEPARTMENT.

E. TAPPAN TANNATT, *Irrigation Engineer.*

As it is necessary to make an annual statement of the work and condition of the Irrigation department of the Experiment Station, I am pleased to report as follows:

Having taken charge of this department in September last, a very large part of the time available has been spent in the examination of the work and records of the office and properly recording and indexing the same.

Even in the very limited time I have been engaged in the work, I have become convinced that the Irrigation department has in this state a most excellent field open to it in which to conduct investigations of value and interest to the state and to the United States.

After familiarizing myself with the records of the office, I have given some little time investigating the existing conditions with a view of conducting investigations in sections most needing the same, and from whence the best results can be secured. I find that this department is unfortunately almost entirely without the instruments necessary to conduct investigations, scarcely having a single equipment for either land or water measurements. During the past, through co-operative work with the departments in Washington, a number of instruments have been loaned the Station for conductive investigations, with the result that most of the data thus secured has been given to the Washington offices with but little return to this department. As the Washington authorities are now making investigations in other sections, it leaves the department almost entirely without the instruments necessary to properly carry on its work.

The Irrigation department of this station can be, and should be one of the most useful, if not the most useful department of the Station to the farmers and citizens of this state, and I would earn-

estly urge that the legislature be requested to assist in properly providing the equipment necessary to conduct the investigations which are so much needed in this state. I find that there are some very serious drainage questions in several parts of the state, also seepage, and thousands upon thousands of dollars can be saved to the people of this state if investigations are conducted in the several localities which will lead to an economical method of overcoming the difficulty.

In the matter of drainage, the investigations carried on near Billings have been conducted up to the present time, or until frost forced their discontinuance. These investigations, owing to the lack of necessary instruments and funds, have not been as satisfactory as they should have been; at the same time some very valuable data has been secured. It is expected to continue these investigations, modifying the work somewhat, with the hope of securing more accurate and satisfactory results.

Considerable work has been done in the neighborhood of Dillon, to secure the duty of water in that section. As the crop returns have not as yet come in from this section, I am not able to advise you as to the value of the work thus accomplished.

The Civil Engineering department of the College, having added a course in highway construction, and commenced investigations with a view of the betterment of public roads in the state, and as we now have every assurance of the active co-operation of the office of Public Roads of the national government in this matter, it is earnestly requested that in the allotment of the appropriation for the ensuing year, that the Station set aside and place in the hands of this department a reasonable sum of money with which it may assist in these investigations, and accomplish work along these lines. I believe that much good can be done in assisting the officers of the counties and state in improvement of their wagon roads along recognized scientific and modern lines. These investigations are eminently a part of the Station's field. I know of no item more important to the wealth and convenience of the state, than good public roads, and the proper expenditure of the road funds. This department has in the course of preparation a bulletin, designed especially for the use of the road supervisors and farmers of this state, who are interested in the betterment of public

wagon roads. With virtually no funds available for this work, it makes it very difficult to produce results which are satisfactory.

I would further call your attention to the following: The Civil Engineering department of the College and the Irrigation department of the Station are, as you are aware, in charge of one man, without assistance. In order that the Engineering department may be built up to a standing commensurate with its importance to the state of Montana, it will require the untiring and almost constant effort of the head of this department. In order that the best results may be obtained for the Irrigation department, it is necessary that it be under competent engineering supervision and that they personally inspect and even conduct the experiments. It is very necessary that the records taken are accurate and correctly reported to the office, and that they are carefully compiled and recorded; in order to secure the same it is often necessary for the irrigation engineer to personally inspect, or even take the records himself. Owing to lack of funds, it has often been necessary in the past to depend upon inexperienced persons to take records for the department and to report same. This method is bound to prove unsatisfactory and possibly misleading. Many of the records taken during the past year have been found to be incomplete, or inaccurately reported, with the result that they are of very little value. It is the intention of the department to avoid as much as possible in the future, the employment of this class of assistance, believing it better to conduct less experimental work and have same as nearly perfect as possible, than to scatter the work over a larger field with uncertain results.

You will at once recognize that for the head of the department to properly carry on such work it is necessary, under the present conditions, for him to leave his classes without a teacher for more or less extended periods of time. This is not only unsatisfactory to the head of the department in engineering, but has a decidedly injurious effect upon the work of both departments. I am free, therefore, to advise you, that under the present arrangement, I consider it absolutely impossible for one man to make a success of both of the above mentioned departments; either one or both must suffer. I, however, believe that the work of the two departments can best

be conducted under the one head, as much of the civil engineering and irrigation work is one and the same and can be carried on at less expense to both departments where thus combined. I would therefore recommend that the Station and the College furnish the department with an assistant, whose duties shall be to assist both the civil and irrigation departments as occasion demands. Such a man need not be an experienced person, but should be a civil engineer. I would recommend the appointment of some young graduate engineer, who desires to specialize in irrigation work.

• Since taking office, a considerable quantity of correspondence has been carried on, both with a view of seeking information along contemplated lines of work and in answer to inquiry. It seems that the impression has become somewhat general that the Irrigation department is for the purpose of answering technical questions raised by citizens of the state, along engineering lines. During the past month the department has received numerous inquiries requesting the calculation of special problems; in many of these cases the information furnished has been insufficient to make satisfactory reply. Although we have calculated and returned a large number of such since September 1st, we believe that, except in special cases, such line of inquiry should not be encouraged, for three reasons: 1st, This office is not supplied with sufficient assistance to carry on this class of extensive correspondence; 2nd, That such calculations are generally unsatisfactory to both parties, owing to the lack of complete information concerning the conditions at the point of application, and the risk that through partial information a wrong impression may be obtained and an incorrect answer returned; 3rd, That such work, by all rights, belongs to the young engineers graduating from this and other colleges who are qualified to inspect and report on the same, and who must depend upon just such work to obtain return for their time and money expended in securing their educations. I believe that the work of this department is to conduct original research work, and to secure advanced information, through which the Station may impart to the people, through its bulletins, information which will be of value to all the people, and that its duty is not to answer special questions and furnish free, information which should be purchased of established professional men of the state.

This department has in mind (appropriation permitting) the study of the following questions in the future:

1st. An investigation of the seepage conditions of the state, with a view of discovering, if possible, some means of economically bettering the same.

2nd. The investigation of the question of applying wind and gasoline power to the drainage and irrigation conditions of the state.

3rd. The further investigation of the drainage conditions at Billings, with a view of deriving information concerning same, and, if possible, discovering a means of bettering the conditions of the Yellowstone valley.

4th. The obtaining of the duty of water, at the Station, and in the Yellowstone valley, and possibly some other point.

The character and amount of work we can carry on as above outlined will largely depend upon the amount available for the purpose, and the character of assistance we are able to employ.

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Note—R indicates the Twelfth Annual Report.

**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION.**

F. B. LINFIELD, Director

THIRTEENTH ANNUAL REPORT.

**FOR THE
FISCAL YEAR ENDING JUNE 30,
1906.**

**Bozeman, Montana
February
1907**

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION.

BOZEMAN, MONTANA

STATE BOARD OF EDUCATION

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A. J. GALEN, *Attorney General*

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} *Ex-Officio*

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F. B. LINFIELD, B. S. A., *Director*.

R. A. COOLEY, B. Sc., *Entomologist*

V. K. CHESNUT, B. Sc., *Chemist*.

R. W. FISHER, B. S. *Horticulturist*.

E. TAPPAN TANNATT, B. S., *Rural Engineer*

W. J. ELLIOTT, B. S. A., *Dairyman*

ALFRED ATKINSON, B. S. A., *Agronomist*

ROBERT W. CLARK, B. Agr., *Animal Industry*.

EDMUND BURKE, *Meteorologist and Assistant Chemist*

FRANK HAM, M. S., *Assistant Chemist*

ANDREW P. ANDERSON, *Assistant Engineer*.

DEANE B. SWINGLE, M. S., *Assistant Botanist*.

J. B. NELSON, *Sup't. Dry Farm Work*.

Post Office, Express and Freight Station, Bozeman.

All communications to the Experiment Station should be addressed to

THE MONTANA EXPERIMENT STATION,

Bozeman, Montana

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

LETTER OF TRANSMITTAL.

Bozeman, Montana, December 31, 1906

To His Excellency, Joseph K. Toole,

Governor of Montana.

Dear Sir:—In accordance with the Congressional Act of March 2, 1887, I have the honor to transmit herewith the thirteenth annual report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1906, the results of investigations of the several departments are reported to the end of the State year, November 30, 1906.

Very respectfully,

F. B. LINFIELD,

Director.

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REPORT OF THE TREASURER.

HATCH FUND.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1905-1906.

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1906, as per Act of Congress approved March 2, 1887.....\$15,000.00

Cr.

By Salaries.....	\$ 9,464.72
Labor.....	2,462.05
Publications	1,062.31
Postage and stationery	329.78
Freight and express	473.28
Heat, light, water and power.....	67.76
Chemical supplies.....	280.15
Seeds, plants and sundry supplies.. ..	
Fertilizers.....	
Library.....	141.99
Tools, implements and machinery....	260.10
Furniture and fixtures.....	85.65
Scientific Apparatus.....	357.21
Contingent expenses.....	15.00
Total.....	<u>\$15,000.00</u>

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana, for the fiscal year ending June 30, 1906; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00, and the corresponding disbursements \$15,000.00; for all of which proper vouchers are

on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed: .

E. B. LAMME,

JOHN M. ROBINSON, Auditors.

Attest: PETER KOCH, Custodian.

ADAMS FUND.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1905-1906.

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1906, as per Act of Congress approved March 20, 1906.....\$ 5,000.00

Cr.

By Salaries.....	\$ 1,037.50
Labor.....	290.97
Publications.....	
Postage and stationery.....	5.20
Freight and express.....	51.60
Heat, light, water and power.....	
Chemical supplies.....	
Seeds, plants and sundry supplies....	4.35
Fertilizers.....	
Library.....	
Tools, implements and machinery.....	
Furniture and fixtures.....	
Scientific apparatus.....	784.04
Travelling expenses.....	32.15
Contingent expenses.....	211.32
Balance.....	2,582.87

Total.....\$5,000.00

We, the undersigned, duly appointed Auditors of the Corpora-

tion, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1906; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$5,000.00, and the corresponding disbursements \$2,417.13; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving a balance of \$2,582.87.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 20, 1906.

Signed:

E. B. LAMME,

JOHN M. ROBINSON, Auditors.

Attest: PETER KOCH, Custodian.

SUPPLEMENTARY STATEMENT.

Experiment Station Miscellaneous Fund.

Dr.

	State.	Farm Produce.
To Receipts	\$5,424.44	\$4,825.62

Cr.

By Salaries.....	333.48	1,000.00
Labor.....	737.07	1,882.66
Publications		
Postage and stationery.....	140.84	
Freight and express.....	104.21	
Heat, light and water.....	708.96	
Chemical supplies.....	49.00	
Seeds, plants and sundry supplies.....	483.26	496.82
Fertilizers	15.00	39.81
Feeding stuffs..	375.93	409.11
Library		
Tools, implements and machinery	319.50	
Furniture and fixtures.....	184.72	
Scientific apparatus	99.25	
Live Stock	150.00	836.00
Traveling expenses	767.82	81.70
Contingent expenses.....		
Buildings and repairs.....	955.40	79.52
Total.....		\$10,250.06

REPORT OF THE DIRECTOR.

With the passage of the Adams Act by the United States Congress in the spring of 1906, the agricultural experiment stations entered on a new era in their work and development.

This act gave to the experiment station in each state \$5000.00 for the year ending June 30th, 1906, this sum to be increased \$2000.00 per year till the total equaled \$15000.00 per year.

The supervision of the expenditure of this fund, by the state, is placed under the direction of the Secretary of Agriculture.

In a letter sent to the Experiment Station soon after the passage of this act, the Secretary says:

"The Director of the Office of Experiment Stations is hereby designated my representative in all matters relating to the business of this Department in connection with the administration of this law, and the Office of Experiment Stations will aid in promoting effective work under this act in the same general way as it has heretofore in relation to the Hatch Act.

"Under the terms of the act, it will be necessary that a separate account of the Adams fund shall be kept at each station, which should be open at all times to the inspection of the Director of the Office of Experiment Stations, or his accredited representative.

"In the interpretation of this act and the examination of the work and expenditures of the stations under it, I have instructed the Director of the Office of Experiment Stations to be guided by the following principles:

"The Adams fund is "to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States." It is for the "more complete endowment and maintenance" of the experiment stations, presupposing the provision of a working plant and administrative officers. Accordingly, expenses for administration, care of buildings and grounds, insurance, office furniture and fittings, general maintenance of the station farm and animals, verification and demonstration experiments, compilations, farmers' institute work, traveling, except as is immediately connected with original researches in progress under this act, and other general expenses for

the maintenance of the experiment stations, are not to be charged to this fund. The act makes no provision for printing or for the distribution of the publications, which should be charged to other funds."

This shows that the use of the Adams Fund is very closely restricted.

The Station is at present working to the limit of the funds available. It is evident, therefore, if we are to use the Adams Fund, as the Secretary of Agriculture has ruled, we will have to increase the funds for Maintenance and for Administration.

The Adams Fund has to be used for original work only and has to go wholly into new lines of work. It is not intended to help on the work now being done but to enable the Station to take up new and original problems. It would appear, therefore, that while the state should supplant the Hatch Fund, it must supplement the Adams Fund, if we are to make proper use of it.

Following out the instructions of the Secretary of Agriculture, the Director of the Office of Experiment Stations, U. S. Department of Agriculture, asked the Station to specify in detail the problems to be undertaken with the Adams Fund and how the money is to be expended on each problem. For instance, the expense for each problem has to be outlined as follows, using as illustration one of the problems undertaken:

Problem:—Insects affecting the sugar beet industry in Montana.

Expense for year ending June 30, 1907.

Salary of expert in charge	\$1000.00
Salary of assistant	400.00
Labor	100.00
Equipment	135.00
Supplies	60.00
Books	25.00
Freight and Express	25.00

Total\$1745.00

This, it is readily seen, leaves out many items needed to make the working out of the problem possible; viz:—buildings and things needed for maintenance, administration, printing, etc.

Up to date, we have estimated on but seven problems and

probably eight will be as many as we will be able to take up when the full fund is available. When any of these are worked out, of course, others will be taken up.

The problems outlined to date are:

- (1) Insects affecting the sugar beet in Montana.
- (2) Disease of apple trees, caused by the action of parasitic fungi.
- (3) Artificial incubation of eggs.
- (4) Development of a sugar beet suited to dry land conditions.
- (5) The movements of soil moisture in irrigated and non-irrigated soils.
- (6) How nitrates are formed in irrigated and non-irrigated soils.
- (7) The cause, cure and control of seepage water from irrigation ditches.

At the present time some of those problems are partly supported from other funds. That is, the man carrying on the "Adams" problems is also engaged in other lines of investigation and some apparatus, travelling and other expense is divided up between the problems, making the expense less for each. Again, in some departments practically all the travelling expense is provided from other sources than the Adams Fund.

IMPROVEMENTS.

It is probable that less has been put into improvements by the Experiment Station during the past year than for any year during the four years the writer has been connected with the Station.

To properly provide for the Botanical work of the College, a green-house, 22 feet by 50 feet, was built on the south of the Station building, with an entrance from this building. This green-house cost about \$1000.00, about \$200.00 of which was contributed by the Station.

A few head of pure-bred live stock were also obtained during the year. Mr. John B. Welcome, of Waterloo, Montana, loaned the College a small herd of Herefords, consisting of a bull and five cows.

From Dr. Mills of Missoula the College purchased one Jersey cow and he presented to the College another cow, a young bull and a

heifer calf. While used mainly for instruction purposes, these animals afford opportunity for some experimental work.

A very substantial improvement came as a result of some drainage tests by the Engineering department. As a result of this work some five or six acres of wet lands that had been rendered partially useless by seepage have been practically reclaimed. To utilize the water developed by the drainage a windmill and gasoline engine has been set up and a reservoir constructed, which will permit of the irrigation from this source of fifteen or twenty acres of the College farm.

WORK OF DEPARTMENTS.

With the additional help from Adams Fund the Station was able to enlarge materially its work for the year. The Adams appropriation went to four departments; viz: Biology, Chemistry, Agronomy and Irrigation.

The work of the Biological Department has extended during the year. The addition of an assistant in Botany makes possible the taking up of studies in plant diseases and considerable work is planned in this direction.

Under the Adams Act, two problems are being taken up by the department; one in entomology and one in fungus diseases, and considerable time is being concentrated by the department on these problems.

In addition to the above, studies have been made of several insects, some of which appear to be new to science. Among these are:

- (1) A moth in the larval stage destroying the inside of the fir cone.
- (2) A beetle larva and other insects feeding on the various species of Populus.
- (3) A small moth on the spruce.
- (4) Cut-worms on winter wheat.
- (5) Parasites of grasshopper eggs.

Additions have also been made to the insect collections and some time spent in naming and arranging them.

In the Chemical department, the work taken up under the Adams Act were new problems. The chemist is also doing some

work for the Adams problems of other departments.

The work with sugar beets, in testing the value of home grown seed, was continued in co-operation with the United States Department of Agriculture.

Some food tests were made of various dried and canned meats and of vinegars sold in the state.

The Agronomy department has undertaken two problems under the Adams Act and these are entirely new and are additions to the work already in hand.

In a state with such a large area and of wide variety of conditions, the demands upon the Agronomy department for information are most pressing.

The department has undertaken extensive variety tests of potatoes, sugar beets, flax, oats, barley, peas and fall and spring wheat, grasses and alfalfa. New varieties are obtained from different parts of the United States and Canada and many are obtained from foreign countries through the U. S. Department of Agriculture. These are tested on the Station grounds through a series of years and those which prove superior are distributed over the state.

In addition to this, tests of soil and crop management are being conducted. Tests of different kinds of fertilizers, different rotations, the effect of irrigation on crop yield and upon the quality of the crop and the effect of different methods of soil cultivation.

During the past year, work in corn acclimation was undertaken in the Yellowstone and Bitter Root Valleys with the object of finding a dent corn that would mature and yield heavily in these valleys. On timbered land in the western part of the state crops were not successful, though the land looked rich. Tests have been undertaken to explain and overcome the difficulty.

The department has also been in immediate charge of the dry farm sub-stations, of which there are seven in various parts of the state. This work was only started the past year.

During the year the department has turned over to other departments for feed 128 tons of hay, 1050 bushels oats, 80 bushels wheat, 40 bushels barley and 9½ tons of sugar beets, valued at about \$1,219.50.

The Irrigation department under the new management has decided to concentrate its efforts on a few lines. For various reasons it was not found possible to connect up closely with the work

previously done in the Department. It was decided, therefore, to take up but one main though broad line of work; viz: The cause, control and cure of seepage water. This problem will be taken up mainly under the Adams Fund.

In following out the plans outlined, studies have been carried on at the Station farm and also near Billings.

During the year, through the generosity of the manufacturers, a double power windmill, a gasoline engine and a pump have been installed by the department and these will be available for further study during the coming season.

The Horticultural Department has enlarged its work during the year. Considerable time was spent in an orchard survey of the Bitter Root Valley, so as to get by personal inspection some accurate knowledge about the orchards and orchard practice of this, the oldest fruit growing valley of the state.

Work has also been continued on the study of the effect of thinning fruit in orchards in the Bitter Root Valley.

At the Station farm, tests of vegetables, of ornamental trees and shrubs and of variety of tree and bush fruits have been continued.

The Dairy Department has been studying the effect of age on the churnability of the cream and upon the character of the butter. Some careful studies have also been made of the causes of variation in the richness of cream from a separator run apparently under like conditions.

The department has kept in touch with the creameries of the state, visiting all of those at present running in the state, giving instructions to both makers and patron. During the year the State Dairymens' Association was organized and the head of the Dairy Department is secretary of this association.

The Animal Industry Department has continued the work of previous years; no new work being undertaken. In co-operation with the Dairy Department, plans were laid to find the returns in milk and increase in live weight obtained from the cows and young stock upon the Station pasture. The results of this are given in the report of the Dairy Department.

SUB-STATIONS.

Through an agreement entered into between the Northern Pacific Railway, the Great Northern Railway and the Montana Experiment Station, the dry farm experiment work was materially extended during the past year. The Northern Pacific Railway contributed \$2500.00 and the Great Northern gave \$2000.00 for the year. In addition free transportation was given for the men engaged and the material used in the work. The Experiment Station put \$1000.00 of State funds into this dry farm work. On the solicitation of the railroads the stations at Miles City, at Dillon and at Helena were discontinued. Work, however, was continued at Thirteen Mile Creek, north of Glendive and a new station was established at Forsyth and another in the Lake Basin country, twenty-five miles north of Billings.

In the northern part of the state in addition to Wayne, a station was started at Shelby and another some twenty-five miles north of Harlem. In addition to the contributions from the railroads the people of Harlem drilled a well, built a small house and fenced about 200 acres of land at a cost of about \$300.00 to \$350.00. At the request of the Director, Representative Dixon and Senator Carter got a bill through Congress setting aside for the dry farm work the section of land selected for the work north of Harlem. At Forsyth the local people donated \$110.00 to help the work at the station near that place.

The Experiment Station and the state are under many obligations to the railroads and to the people of these localities for their generous support for this work.

CO-OPERATIVE EXPERIMENTS.

During the year co-operative work was continued with the Northern Pacific Railway, which contributed \$2500.00 toward the carrying on of dry farm tests at Billings, Forsyth and Glendive.

The Great Northern Railway entered into this co-operation the past year and contributed \$2000.00 toward carrying on dry land experiments at Shelby, Harlem and Wayne. The help given toward this dry farm work by the railways has made it possible for us to take up extensive studies along this line, whereas without this help little or nothing could have been done.

Up till June 30th, 1907, the Poison Plant Division of the Bureau of Plant Industry, U. S. Dept. of Agriculture continued co-operation with the Station, but owing to lack of funds could not continue beyond that time.

NEEDS OF THE STATION.

The passing of the Adams Act with the additional funds which comes to the Station as a result, makes still more imperative the needs of the Station for more room and equipment. We have called attention to these needs in the reports of the past two or three years. Our needs in this direction have increased with the passing time and we hope with the improved financial condition of the state, something may be done during the coming winter to relieve the crowded condition of the agricultural and biological departments of our work.

THE STATION STAFF.

With the increase in the funds and work of the Experiment Station, the Director felt that he could no longer give to the work in Animal Industry the attention it should have. In view of this fact, R. W. Clark, Prof. of Animal Industry at the Utah Station, was engaged to take charge of this department. Prof. Clark asked leave of absence to study in the East for some months and takes up his work at the Station on Jan. 1st, 1907.

In view of the increase in the funds of the Station and the need of expert help in carrying on the work under the Adams Act, several assistants were added to the staff. Mr. Andrew P. Anderson, a graduate from Pullman, Washington, was engaged as assistant in the Engineering Department.

In the Chemical Department, Mr. Frank Ham, a graduate of the College, was engaged as Assistant Chemist.

Mr. Dean B. Swingle, a graduate of the Kansas Agricultural College and also of the University of Wisconsin and who for five years was employed by the Bureau of Plant Industry, United States Department of Agriculture, was engaged as Assistant Botanist and took hold of his work on September 1st, 1906.

Mr. J. B. Nelson, who was Assistant Agronomist at the Utah

station, was engaged in March 1906, as Superintendent of dry farms and will give his entire time to the dry farm work.

AGRICULTURAL EXTENSION WORK.

In its growth and development, the work of the agricultural college seems to trend toward a division into three main lines:

1st. **The Agricultural Experiment Station**, which devotes its energies to finding out new facts and formulating correct methods of agricultural practice from these new facts. It furnishes the facts upon which are based the agricultural instruction by the College.

2d. **The Agricultural College**, where the facts and formulas worked out or verified by the Experiment Station are presented in pedagogic form to the young people who come to us for such instruction.

3d. There is the **Extension Work** of the College, through which we aim to reach all the people of the state and to help them toward a better, more profitable, and more enjoyable agriculture.

The present activities in this direction are listed as follows:

- (a) The Farmers' Institute work.
- (b) Correspondence.
- (c) Tests and demonstration of various kinds, chemical analysis, seed testing, etc., inspection work, etc.

These lines of instruction, it appears to me, are logical outgrowths of the Experiment Station and Agricultural College work and heretofore the expense of providing for much of this work has been borne by the College and Experiment Station without any special appropriation. The travelling expenses of the men sent on Farmers' Institute work have been paid, but the time of these men has been contributed free of cost. Had this time been paid for it would have added a great deal to the cost of the work.

FARMERS' INSTITUTE.

During the past year the Station and College officers spent 110 days in the field on Farmers' Institute work. In addition to this, considerable time was given to preparation of the lectures and the Director spent a large amount of time in advertising the meetings and in editing and printing the Annual Report of 300 pages.

The number of Farmers' Institute meetings are growing rapidly. In 1902-3 forty-three meetings were held in thirty-five towns of the

state. In 1905-6 one hundred and thirty-three meetings were held in seventy-seven towns of the state and the attendance increased from about 2000 to close to 8000 people.

The Director of the Experiment Station being a member of the Board of Farmers' Institutes and also Secretary of the Board and Superintendent of the Institute work for the state, upon him devolves the responsibility for the success of the work. Again, as the state as yet lacks a trained body of agriculturists who can find time to help at those meetings, the weight of the work falls upon the members of the Station staff.

The College and Experiment Station work, however, is rapidly growing in magnitude and must not be neglected. If therefore, the Farmers' Institute and agricultural extension work is to grow and prosper, we have about reached a time when it must be made a department of the institution and given the help and financial support necessary to its proper development.

CORRESPONDENCE.

Through correspondence in answer to inquiries on practical agricultural questions and by articles to the press, the Experiment Station is conducting a large correspondence school. The demands in this direction are continually increasing. For the past year 4700 letters were sent out. During the year two clerks have been employed who have devoted most of their time to this correspondence. By departments the letters were as follows:

Director's office, 1159 letters; Chemical Department, 600 letters and 600 to 700 circular letters; Biological Department, 575 letters and a few circular letters; Agronomy Department, 766 letters and 198 circular letters; Irrigation Department, 410 letters, giving information and 200 letters of inquiry, etc.; Horticultural Department, 591 letters and 674 circular letters; Dairy Department, 792 letters; Poultry etc., 200. This makes a total of about 4700 letters and 800 circular letters for the year. This shows an increase of about 300 letters over the past year.

TESTS AND DEMONSTRATIONS.

There is yet another kind of information demanded of us which at times, because of the expense in time and material involved, makes serious inroads upon our work. Probably our Chemical De-

partment has to meet more of these demands than any other. Some people would like to get a soil analyzed; others would like to have water tested; again some food product, it is desired to have tested for an adulterant or poison, etc. Our Engineer is requested to travel a few hundred miles to inspect a system of weirs, or to inspect a ditch, or to pass upon an irrigation or small waterworks system or to test samples of cement. Our Biological Department is asked to make bacteriological examinations of various kinds; the Agronomy Department to test seeds, and the Dairy Department to test milk.

Now, I think the people of the state can readily see that if we were to throw the door wide open and do this work free of charge to all who asked we might do nothing else, and so neglect the especial duties that we are placed here to perform.

All will admit that it is not an easy matter to draw the line as to how far it is allowable to go in these matters. Tests which involve but little time or expense, as the testing of milk and seeds or grain, may be readily taken care of, but those that involve large expense in time and material are another matter. As a rule, the Experiment Station is not prepared to make any tests along the above lines for any individual or company, unless the results have a bearing on work being carried on by the Station or if the results have a wide general interest.

I believe our friends over the state will recognize that if we are to carry on original investigations in the agricultural field, we cannot burden our time with miscellaneous tests and analysis which may have no relation whatever to the work we have in hand.

PUBLICATIONS OF THE YEAR.

Four bulletins and the thirteenth annual report were published during the year. These contain 184 pages of printed matter and 24 plates.

Bulletin No. 63:—Dry Farming in Montana, by F. B. Linfield, and Alfred Atkinson, Agronomist, presents first a survey of the probable favorable sections of the state for dry farming and then discusses some dry farming principles and practices, based on a preliminary study of the problems in Montana. Thirty-two pages and eleven plates.

Bulletin No. 64:—The Fourth Annual Report of the State En-

tomologist, by R. A. Cooley, Entomologist. This is a brief report of the work of the year together with a few notes on insects that have been troublesome. Thirteen pages.

Bulletin No. 65:—Seepage and Drainage, by E. T. Tannatt, Rural Engineer. A discussion of observations on the ground water and drainage of a section of the Experiment Station farm. Nine pages and four plates.

Bulletin No. 66:—An Orchard Survey of the Bitter Root Valley, by R. W. Fisher, Horticulturist. This bulletin gives the result of a careful study of the orchards of the Bitter Root Valley, noting the varieties grown, the management given and the results from such orchards. The results are supplemented by deductions from the observation made. Thirty-two pages and seven plates.

The Thirteenth Annual Report:—The report of the Director on the work and observations of the year, and also reports of the heads of each department, giving results of some of the work of the year.

MAILING LIST.

The Station mailing list continues to increase. For the past year an edition of 6,000 copies have been issued. About 3,500 copies are distributed in the state. 600 copies are sent to persons interested in our work over the United States. Over 700 copies go to officers and others at the agricultural colleges and experiment stations of the United States, and 50 copies are sent to foreign countries.

LIST OF STATION PUBLICATIONS.

1. Organization—Announcements.
2. Smuts of Wheat, Oats and Barley.
- * 3. Pig Feeding.
- * 4. Glanders.
- * 5. First Annual Report, Crop Statistics of Gallatin County.
- * 6. Measurement of Water.
- * 7. Small Grains and Potatoes.
- * 8. Second Annual Report—Crop Statistics of Gallatin County—Parasitic Ictero—Haematuria of Sheep.
- * 9. Potatoes.
- * 10. Small Grains, Wheat, Oats, Barley.
- * 11. Devices for Obtaining a Constant Flow in Laterals with Variable Heads in the Main Canals or Reservoirs.

12. Third Annual Report, Spaying of Mares.
13. Drinking Water.
14. Montana Swine Feeding.
15. Larkspur Poisoning of Sheep.
16. Fourth Annual Report.
17. An Army Cut Worm—The Grain Aphis.
- *18. The Alkali Soils of Montana.
- *19. The Sugar Beet in Montana.
- *20. Fifth Annual Report.
- *21. Sheep Feeding.
- *22. Thirteen Botanical Subjects.
- *23. Injurious Fruit Insects; Insecticides; Insecticide Apparatus.
- *24. Sixth Annual Report.
- *25. Paris Green, and London Purple.
- *26. Poultry Raising.
- *27. Live Stock Feeding Tests, Beef Cattle, Lambs and Swine.
- *28. Seventh Annual Report.
- *29. Quantity of Water Used in Irrigation.
- *30. Weeds of Montana.
- *31. Report of Grazing and Feeding Tests, Beef Cattle and Lambs.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
34. Farmers' Weirs.
35. Report of Feeding Tests.
36. Forage Conditions in Montana.
37. Pork Production in Montana.
38. Food Adulterations.
- *39. Sheep Feeding in Montana.
40. Root Crops in Montana.
41. Sugar Beets, (1902).
42. The Codling Moth.
- Ninth Annual Report.
43. Duty of Water.
44. Apple Growing in Montana.
45. The Loco, and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
49. Contagious Abortion in Montana.
- *50. Poultry Management and Poultry Diseases.
51. First Annual Report of the State Entomologist.
- Tenth Annual Report.
52. Sugar Beets.
53. Creameries and Cheese Factories.
54. The Alkali Soils of Montana.

55. Second Annual Report of the State Entomologist.
Eleventh Annual Report.
56. Native Economic Plants of Montana.
57. Feeding Pigs.
58. Fattening Cattle.
59. Sheep Feeding.
60. Onion Culture.
61. Food Adulterations.
62. Third Annual Report of the State Entomologist.
- * Twelfth Annual Report.
63. Dry Farming in Montana.
64. Fourth Annual Report of the State Entomologist.
65. Seepage and Drainage.
66. Orchard Survey of the Bitter Root Valley.
Thirteenth Annual Report.

*Out of Print.

EXCHANGE LIST.

Agricultural Economist, Spencer, Indiana.
 American Fancier, Johnstown, New York.
 American Fertilizer, Philadelphia, Pennsylvania.
 American Hay, Flour and Feed Journal, Milwaukee, Wisconsin.
 American Poultry Advocate, Syracuse, New York.
 American Poultry Journal, Chicago, Illinois.
 Beet Sugar Gazette, Chicago, Illinois.
 Big Timber Pioneer, Big Timber, Montana.
 Billings Times, Billings, Montana.
 Bozeman Chronicle, Bozeman, Montana.
 Butte Inter-Mountain, Butte, Montana.
 Chicago Daily Drivers' Journal, Chicago, Illinois.
 Chicago Dairy Produce, Chicago, Illinois.
 Chicago Live Stock World, Chicago, Illinois.
 Chicago Markets, Chicago, Illinois.
 Chinook Opinion, Chinook, Montana.
 Coleman's Rural World, St. Louis, Missouri.
 Daily Independent, Helena, Montana.
 Dairy Record, St. Paul, Minnesota.
 Deseret Farmer, Provo, Utah.
 Dillon Examiner, Dillon, Montana.
 Dillon Tribune, Dillon, Montana.
 Farmers' Advocate, Winnipeg, Manitoba.
 Farmer & Breeder, Sioux City, Iowa.
 Farmers' Guide, Huntington, Indiana.
 Farmers' Review, Chicago, Illinois.
 Farm, Field and Fireside, Chicago, Illinois.
 Farm Home, Springfield, Illinois.

Farm Journal, Philadelphia, Pennsylvania.
Farm Progress, St. Louis, Mo.
Farm News, Springfield, Ohio,
Farm, Stock & Home, Minneapolis, Minnesota.
Farm Poultry, Boston, Mass.
Feather, Washington, D. C.
Fruit Grower, St. Louis, Mo.
Furrow, Moline, Illinois.
Gallatin County Republican-Courier, Bozeman, Montana.
Gem State Rural, Caldwell, Idaho.
Gleanings in Bee Culture, Medina, Ohio.
Glendive Independent, Glendive, Montana.
Great Falls Weekly Tribune, Great Falls, Montana.
Home & Farm, Louisville, Ky.
Horticultural Visitor, Kimmunity, Ill.
Hospodar, Omaha, Neb.
Independent, Miles City, Montana.
Irrigation Age, Chicago, Illinois.
Jersey Bulletin, Indianapolis, Indiana.
Kansas Farmer, Topeka, Kansas.
Kimball's Dairy Farmer, Waterloo, Iowa.
Livingston Post, Livingston, Montana
Madison County Monitor, Twin Bridges, Montana
Madisonian, Virginia City, Montana.
Milk River Valley News, Harlem, Montana.
National Farmer & Stockgrower, St. Louis, Mo.
National Farmer, Winona, Minnesota.
Nebraska Farmer, Omaha, Neb.
Northwest Poultry Journal, Salem, Oregon.
Northwest Tribune, Stevensville, Montana.
Northwestern Stockman & Farmer, Helena, Montana.
Orange Judd Farmer, Chicago, Illinois.
Oregon Agriculturist, Portland, Ore.
Pacific Coast Fancier's Monthly, San Jose, Cal.
Pacific Dairy Review, San Francisco, Cal.
Pacific Fruit World, Los Angeles, Cal.
Pacific Poultryman, Tocomo, Washington.
Park, Cemetery and Landscape Gardening, Chicago, Illinois.
Plainsman, Plains, Montana.
Poultry Herald, St. Paul, Minn.
Poultry Husbandry, Waterville, New York.
Poultry Success, Springfield, Ohio.
Prairie Farmer, Chicago, Illinois.
Rocky Mountain Husbandman, Great Falls, Montana.
Republic, St. Louis, Mo.
Rural New Yorker, New York.
Semi-Weekly Missoulian, Missoula, Montana.

DONATIONS AND LOANS.

- American Shock Binder Co., Richmond, Va. One shock binder.
- Double Power Mill Co., Appleton, Wis. One 14 ft. steel wind-mill, also cuts of mill and station grounds.
- Link Belt Mfg. Co., Chicago, Ill. One link pump No. 2
- The International Harvester Co., Chicago, Ill. Loaned one 5-horse power gasoline engine.
- Messrs. White and Arnold, Billings, Mont. For drainage investigations, \$45.00.
- Mr. Ed O'Donnell, Billings, Mont. For drainage investigations, \$15.00.
- Mr. Paul McCormick, Billings, Mont. For drainage investigations, use of horse and saddle.
- B. F. Luke Co., Salt Lake City, Utah. One irrigation plow and leveler.
- Office of Vegetable Pathological & Physiological Investigations, Bureau of Plant Industry, U. S. Dept. of A. 50 lbs. beet seed (Kleinwanzlebener.)
- Office of Seed & Plant Introduction, U. S. D. A. 80 lbs. beet seed (Kleinwanzlebener.)
- E. D. Morrison, Fairfield, Wash. 100 lbs. beet seed (Kleinwanzlebener.)
- Edward C. Post, Dundee, Mich. 110 lbs. beet seed (Breustadt's Elite); 50 lbs. beet seed (Breustedt's Elite A.); 50 lbs beet seed (Breustedt's Neuere Zucht.)
- H. Cordes, Glendale, Ariz. 5 lbs. beet seed (Knauer's Mangold; 5 lbs. beet seed (Knauer's Kleinwanzlebener.)
- U. S. Dept. of Agriculture. Use of franking privileges.
- O. S. Chilcot, Rockvale, Mont. 200 silver poplars.
- C. A. Alling & Co., Homer, Minn. 1/2 doz. Homer cherry-trees.
- W. Attlee Burpee & Co., Philadelphia, Pa. Vegetable and flower seeds.
- Bolgiano & Sons, Baltimore, Md. Two varieties tomato seeds.
- M. Langohr, Bozeman, Mont. Hardy annual and perennial plants.
- Elov Errickson, St. Paul, Minn. Lactic acid culture.
- American Acid & Alkali Co., Bradford, Pa. Butter Culture.
- Marshall Dairy Laboratory, Madison, Wis. Dairy cheese color and rennet tablets.
- Frank L. Jones, Utica, N. Y. Cheese pepsin.

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Omega Separator Co., Lansing, Mich. Loaned one 450
ator.

Hastings Industrial Co., Chicago, Ill. Loaned one 450 lb.

Empire Separator Co., Bloomfield, N. J. Loaned separat

Vermont Farm Machine Co., Bellows, Falls, N. Y. Loan
ator.

Alpha Separator Co., Chicago, Ill. Loaned separator.

Dr. W. P. Mills, Missoula, Montana. Three Jerseys.

ANIMAL INDUSTRY DEPARTMENT.

F. B. LINFIELD.

The Animal Industry Department has no special results to report as a result of the past year's work. A carload of steers were fed during the winter but no sheep. An experiment was also conducted with feeding dairy cows. Several lots of pigs were fed in a study of the value of supplemental foods. The results of all these tests are reserved until further experiments are carried out along the same lines. No bulletins were published during the past year.

POULTRY DIVISION.

During the year Mr. J. R. Scott, who had charge of the poultry plant for some eighteen months, resigned to go into business and Mr. Henry Langenschwadt of New York, was engaged in his place.

Some additional improvements have been made in the poultry buildings. In laying house No. 1, described in Bulletin No. 26, roosting pens have been constructed with a curtain front. Some years ago we tried heating this building with a stove and later by means of a hot water coil. Neither proved satisfactory. The coming winter, we will try the roosting pen protected by the curtain front in cold weather.

The laying pens in all of the houses have been provided with an ample number of trap nests so that egg records may be kept of every bird in the pens.

When first equipped, hot water pipes were used to heat the brooders in the brooder house. After two seasons' experience we decided to change. The hot water pipes will be used to heat the house but the brooders will be heated with lamps. With the hot water pipes it seemed impossible, without very much more care than we could give, to prevent the brooders from occasionally getting too cold during changeable weather. The result was a very large loss in our early hatched chicks and a stunted growth in those that survived.

To the breeds of poultry listed last year we have added two

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others; viz. the Buff Orpingtons and the White Plym. This gives us eight representative breeds.

A point that should be called attention to in connection with our poultry is that our plan is to try and develop large numbers of the various breeds. In view of this fact, we will not place fancy points in the selection of our breeding stock, but will place emphasis on egg producing record. We are only beginning to take up this work and so have no pedigreed laying stock at present but have several nests in operation we hope, in a few years, to have in this direction of value to offer. To those who are interested in this work, I would like to say that while we are not going to select fancy bird types and characteristics our principle aim will be to produce utility stock and not fancy or high scoring birds.

NEW POULTRY BUILDING.

The new poultry building, described in the last Annual Report, after a year of service has proved very satisfactory. There has been no trouble from frosted combs, even in extreme cold weather. The birds keep strong and healthy and we are getting more fertile eggs. A larger proportion of fertile eggs than from the birds in the old building which is described in Bulletin No. 26.

EGG RECORDS OF STATION FOWLS.

Table No. 1 gives the egg record of each pen of fowls for the year. It also shows the number of birds in each pen and the number of eggs laid by each bird.

In pen one there were four Light Brahma pullets. They averaged 78 eggs each for the year. The largest number of eggs laid by one bird was 92 and the least 71.

Pen two, White Wyandottes, averaged 70 eggs to a bird. The range was from no eggs to 119 for the year.

Pen three, Barred Plymouth Rocks, averaged 71 eggs to a bird. The range was from 33 to 138 eggs for the year.

Pen four, Single Combed Brown Leghorns, averaged 71 eggs to a bird and the range was from 38 to 119 eggs for the year.

Pen five, Single Combed White Leghorns, averaged 71 eggs to a bird the year. The lowest record was one egg; the highest was 119 eggs for the year.

Pen six, Rose Combed Brown Leghorns, averaged 60 eggs each. The lowest record was 17 eggs and the highest 112 eggs for the year.

Pen seven, Single Combed Brown Leghorns, averaged 85.9 eggs for the year. The lowest record was 26 and the highest 139 eggs for the year.

Pen eight, Single Combed Brown Leghorns, averaged 49.4 eggs for the year. The lowest record was 5 and the highest 100 eggs.

Pen nine, Single Combed Brown Leghorns, averaged 69.4 eggs for the year. No individual records were kept.

Pen ten, White Wyandottes, averaged 70 eggs for the year. The range was from one to 138 eggs for the year.

Pen eleven, Barred Plymouth Rocks, averaged 68 eggs for the year. The range was from 37 to 88 eggs.

Pen twelve, Single Combed Leghorns, averaged 101.5 eggs for the year. This was a pen of pullets and they gave the highest average for the year. No individual records were kept.

Pen thirteen averaged 45 eggs for the year, and pen fourteen averaged 80.5 eggs. No individual records were kept of these pens.

There are two things about this record that we are going to endeavor to change in the next few years, if possible. First, the egg record should be practically doubled; and second, we desire to get the hen to start laying at least two months earlier and to push forward the maximum egg production. This record shows the maximum egg production during April, May and June.

BIOLOGICAL DEPARTMENT.R. A. COOLEY, *Entomologist*.**INSECT COLLECTIONS.**

So far as possible in the limited time available for such work, we have added to our collections of insects and have made some progress in naming and arranging for reference, the collections that have been accumulated since my arrival in Montana. Our Orthoptera, Lepidoptera, Coleoptera and Diptera are now fairly well worked up, yet in all these orders, as well as in the other orders not mentioned, we have a large number of specimens to be named and inserted into the reference collections.

In the discharge of the routine work of the Entomologist's office, we are often reminded of the necessity for a reasonably complete named collection of Montana insects, and we shall continue to collect and name specimens so far as we are able. We have made material additions to our collections through exchange during the past year.

Outside of the executive and routine work of the department, our activities naturally fall under two heads:

- (1) Work conducted under funds other than Adams.
- (2) Work conducted under the Adams Fund.

(1) Under funds other than Adams, the following lines of work are under way:

(a) A moth feeding in the larval stage on the cones of the so-called fir (*Pseudotsuga mucronata*), which is one of our principal forest trees, has caused a loss of a very large proportion of the seeds of these cones on all trees that I have had an opportunity to study in the mountains surrounding this (Gallatin) valley. So far as I have yet been able to learn, this species is new to science and unstudied except by this office. We have been making observations on this species during the past few seasons and have the life-history complete in outline. I hope to be able, during the coming season, to complete these studies and prepare our notes for publication.

(b) A small chrysomelid beetle-larva is feeding extensively on the leaves of various species of *Populus* from Bozeman east, in Mon-

tana. In and around Billings particularly it has been so abundant for several years that many shade trees have been robbed of their beauty if not actually injured. We have this insect under study and hope this coming season to be able to publish our results.

(c) In this same connection I should mention that we are gradually accumulating extensive notes on the various species of insects that effect all those trees belonging to the botanical genus *Populus*. Taking the state as a whole, the various "poplars" are still our main dependence for shade trees and a considerable proportion of our letters written in reply to inquiries from the state deal with insects on these trees. At some future time we shall be able to submit a manuscript with illustrations dealing with some seventy-five species of the insects of *Populus*.

(d) A small caterpillar feeding on spruce needles has been very injurious to trees of this variety in Bozeman and other parts of the state. This species is probably also new to science. For some five years we have been observing its habits and think that we can complete our notes this coming spring and summer.

(e) Parasites of grasshoppers' eggs. In connection with our studies on the life-history of the spotted blister-beetle, *Epicauta maculata*, last season, we were surprised to learn to what extent the eggs of grasshoppers are preyed upon by other species of insects. We, therefore, undertook to study the subject and are accumulating notes. We cannot tell how soon we shall have mature results from these studies, but the subject is of interest as more information may throw some light on the unsolved question of the cause of the fluctuation in the abundance of native grasshoppers. We expect to continue these studies this season as we have opportunity.

(f) Cut-worms on winter wheat. Early in October great numbers of an unidentified cut-worm made their appearance in the wheat fields of the "Flathead District" in the northern part of the Gallatin Valley. To our certain knowledge, many hundreds of acres are more or less affected and in some cases the grain has been completely eaten off. Specimens were at once put in cages in the greenhouse and we shall later be able to name the species from the adult moths when they appear. It will be necessary for us to make some study of the matter next spring and, so far as possible, aid the farmers to protect their grain.

Aside from the above very definite lines of work, much time is necessarily spent in the routine of the department. We are often called upon for various forms of assistance and a single letter of inquiry may occasion much work. We like to encourage such inquiry for we are thereby aided in knowing the need of the state.

(2) Under the Adams Fund we have undertaken the study of the insect pests affecting the sugar beet in Montana. We began the work without much knowledge of what insects would be found other than a considerable number of widely distributed species known to feed on this plant, but we have found a large number at work, both of native and introduced species. While in general the work thus far has been of a preliminary nature, we have made considerable progress in a knowledge of several species and already we have a large number of photographs and also much study material from which to make drawings as well as many notes. To a very gratifying extent, we have found beet growers ready and willing to co-operate with us in this work, a fact which has helped us much toward getting results.

We have had two rather serious hindrances to our work. The building of a greenhouse last summer delayed the work, as it was necessary to have the workmen about the insectary practically all summer. A more serious difficulty was found in the extreme dryness of the atmosphere in the insectary, which made it difficult to keep some delicate forms alive long enough for us to complete our studies. We have purchased a recording hygrometer and during the coming season shall try to keep up the humidity by the addition of moisture.

In pursuing this line of work, we found it necessary to make extensive search of the literature of the subject, and since the insects of sugar beets are scattered through a large number of orders and also since many of them are of old world origin, the search of the literature of the subject necessitates an examination of a very large number of books. Before this work can be completed it will be necessary to either secure many books for our library or visit one or two of the larger libraries of entomology in the East.

On the whole, the year's progress has been satisfactory, but we feel that the next year will produce more extensive results principally because of the fact that the work is now well under way.

APPOINTMENT OF ASSISTANT BOTANIST.

Mr. Dean B. Swingle having been previously appointed as Assistant Botanist, took up his duties on August 21, (1906) and since that time has devoted one-half of his time to experiment station, the other half being occupied by the college. Mr. Swingle graduated from the Kansas Agricultural College in 1900 and went from there to the University of Wisconsin where he took his M. S. degree in 1901. He then accepted a position in the Bureau of Plant Industry U. S. Department of Agriculture, as assistant in pathology, under Dr. Erwin F. Smith. In this position he continued until he came to this institution, except for a leave of absence of one collegiate year in 1903-1904, when he again was engaged in study in the University of Wisconsin. In his studies he has paid particular attention to the physiology of plants, plant pathology and to bacteriology, and we believe him to be particularly well qualified for the duties he is to perform in Montana.

Being a new man in this institution and state, Professor Swingle has necessarily been occupied to a considerable extent in becoming familiar with the conditions and needs that prevail in Montana's agriculture. For some years there has been a great need for study of an obscure group of troubles or diseases on fruit trees. The death of many trees has remained unexplained and there seems to be an opportunity to save much property to the fruit growers of the state. It is intended during the year to take up this line of study.

Professor Swingle has been of considerable service to the medical profession of the state and to the public in making bacteriological tests and determinations. Among these have been tests to determine the presence or absence of tuberculosis, diphtheria and typhoid fever germs.

CHEMISTRY DEPARTMENT.

V. K. CHESNUT, *Chemist.*

During the fiscal year ended November 30, 1906. 289 samples of various sorts, with an average of three determinations for each, were analyzed. Of these analyses 142 were of sugar beets, 65 of soils, 27 of meats, 19 of minerals of economic importance and 16 of vinegars, the remainder being analyses of coal, water and various miscellaneous materials. A number of other substances were submitted for analysis but the requests had to be denied, either on account of improper sampling, or because of the fact that the results would have been merely for private use.

SOILS.

Much of the soil work was in co-operation with the Agronomist of this station, the object in view being to determine the effect of different methods of soil management on soil fertility. This work will have to be repeated for a number of years before satisfactory conclusions can be deduced therefrom.

Analysis of a soil sample representing a large area of barren land near Miles City, showed that it contained over half of a per cent of black alkali. This land is very evidently in need of better drainage or a treatment with gypsum. There are large deposits of this mineral in different parts of the state, and it is believed that if drainage cannot be economically accomplished on these areas, the use of gypsum, as suggested by Prof. E. W. Hilgard of the California station, would be very profitable.

POISONS.

One sample of poisoned meat and one plant were submitted for analysis. The meat contained arsenic mixed with glass, and was thrown out with the intention of poisoning a valuable dog. The plant proved to be a sample of the false California Hellebore, *Veratrum californicum*. The roots of two or three of these plants were eaten by mistake for "wild rhubarb" by two men with nearly fatal results.

LOCOED SHEEP.

Owing to lack of funds the experiment of drenching and then fattening so-called locoed sheep which met with good results on a small scale in 1903-4, had to be discontinued in 1904-5. In November of this year, however, a carload of locoes was purchased, and the feeding experiment is now being carried on at Bozeman. Some of the animals, which are now rapidly putting on flesh, will be sent out again on the range in order to determine whether or not they will again succumb to the disease. This phase of the question is of very great practical importance, not only on account of the loss of sheep entailed, but because the sheep lost represent the young animals from which the normal increase is generally expected.

FOOD POISONING.

Occasional cases of the poisoning of people by canned sea food show that it is desirable in the near future to test some of these goods for ptomaine poisons. This is especially emphasized by the fact that it is a practice with some unscrupulous canners to recan any fish that have begun to spoil, and then to sell this material to ignorant dealers as "Do-overs." The practice is nothing less than criminal and should be stopped by law.

MINERALS AND ROCKS OF ECONOMIC IMPORTANCE.

Two samples of gypsum, representing deposits new to Montana, were submitted for analysis. Both of these deposits are of large extent, and are of value not only for a superior kind of plaster but as a fertilizer for alkaline soils.

Samples of volcanic ash were received from two or three new localities in the state. Analysis shows this ash to be comparatively rich in potash, so that it may be considered as a future source of rock fertilizer. The ash also promises to be of service in the manufacture of a cheap cement for lining irrigation ditches, as well as for general scouring purposes. The crude material was found to be present in large quantity in the so-called "Dutch Cleanser," which is now being generally sold in the Montana market at comparatively fancy prices. The native product compares favorably with the imported material in abrasive action.

One sample of shale obtained near Livingston was analyzed to see if it could be used for the manufacture of Portland cement. The

analysis of this deposit, which is of large extent, gave the following results, viz:

H₂ o. .85%; Si O₂ 67.83; Fe₂ O₃ 3.98; Al₂ O₃ 17.43; Ca O. 1.66; Mg. O. 1.71; Na₂ o. 5.56; K₂ O. 1.15.

WATER.

There is no part of the work of station chemistry which is of more importance to the public in general than the analysis of public water supplies and the station has always considered it a privilege and a duty to analyze samples of water used by our public institutions. One such sample, submitted by the matron of the Orphan's Home at Twin Bridges, received careful consideration. Analysis showed it to be altogether unfit for continuous consumption and on the strength of our work a successful demand was made for a better supply. An analysis of the Bozeman city water showed it to be remarkably free from sewage and other objectionable organic matter.

The state of Montana is still without any special food control law other than the one under the state Veterinarian calling for meat and milk inspection. In this respect it is one of the very few states that does not grant adequate protection to its citizens, and it is, therefore, the recipient of a very full measure of worthless, or poor grade, stock which is colored, flavored or embalmed so as to simulate the genuine and more wholesome article. The great extent of fraud committed in the state calls for immediate investigation.

MEATS AND VINEGARS.

The general police and analytical work required for proper food control is not a part of the duty of the state experiment station which is largely supplied with funds from the United States government, but in order to help protect our agricultural interests, the work of the past year in analyzing meats and vinegars has been continued. A full report on the analyses will soon be ready for the press.

SUGAR BEETS.

The first beet sugar factory in Montana was erected during the past year at Billings at a cost of about \$1,000,000. The plant was completed in time to handle the crop of 1906. 8,000 tons of sugar were produced, and as a result, Billings is now rejoicing over her increasing population and land values, her increasing dairy herds and facilities for stock feeding and, in general, her greater business and commercial prosperity.

Other districts throughout the state are now busily looking into their chances of getting a sugar factory, and the demand for seed and for testing beets is steadily increasing.

Seed was sent out during the year to over three hundred farmers in twenty-five different counties of the state, but the counties taking the most lively interest and from which the most valuable returns were received were the following, viz.;—Gallatin, Missoula, Cascade, Choteau, Fergus, Madison and Ravalli. Reports on each of the several districts have not yet been summarized, but they will be included in a bulletin which is to be issued during the present year. The greatest progress toward securing another factory was made by Gallatin county. It may, therefore, be of interest to examine the following table, showing the results of our analysis of thirty-nine samples of beets raised in this valley. It is given here without comment as follows:

REPORT OF ANALYSIS OF SAMPLES OF SUGAR BEETS FROM GALLATIN COUNTY.

Lab. No.	Farmer's Name	Address	Sugar in Juice.....	Sugar in Beet.....	Purity	Av. Weight in Ounces
3346.	T. S. Kirk, Bozeman.....		9.9	9.4	73.3	28.0
3347.	T. S. Kirk, Bozeman.....		11.3	10.73	77.4	20.0
3349.	G. M. Lewis, Manhattan.....		16.0	15.20	84.1	51.0
3358.	T. S. Kirk, Bozeman.....		18.2	17.3	87.8	26.3
3380.	J. P. Nash, Bozeman.....		17.0	16.2	82.9	25.3
3394.	J. E. Shipman, Bozeman.....		19.1	18.1	90.5	26.0
3395.	J. E. Shipman, Bozeman.....		16.3	15.5	82.7	61.0
3396.	E. Broox Martin, Bozeman.....		15.5	14.7	82.4	44.0
3397.	E. Broox Martin, Bozeman.....		14.0	13.3	76.2	50.0
3399.	T. S. Kirk, Bozeman.....		17.5	16.6	82.6	32.0
3400.	E. D. Ferguson, Bozeman.....		15.8	15.0	82.4	57.0
3401.	E. D. Ferguson, Bozeman.....		14.8	14.06	79.7	44.0
3402.	E. D. Ferguson, Bozeman.....		18.3	17.4	83.6	31.0
3403.	Experiment Station, Bozeman..		16.5	15.7	85.5	27.5
3404.	Experiment Station, Bozeman..		18.4	17.47	85.7	24.0
3405.	Experiment Station, Bozeman..		18.0	17.2	87.8	25.0
3406.	Experiment Station, Bozeman..		20.2	19.2	89.0	18.6
3407.	Experiment Station, Bozeman..		19.1	18.1	90.5	19.3
3408.	Experiment Station, Bozeman..		19.5	18.5	86.7	22.6
3409.	Experiment Station, Bozeman..		18.4	17.46	86.0	23.6
3410.	Experiment Station, Bozeman..		20.0	18.99	88.2	17.0
3411.	Experiment Station, Bozeman..		17.8	16.9	85.6	20.0
3418.	James Martin, Bozeman.....		18.9	18.1	75.5	25.0
3419.	E. Broox Martin, Bozeman.....		14.8	14.06	78.25	61.0
3420.	E. Broox Martin, Bozeman.....		14.0	13.5	78.7	27.0
3425.	Experiment Station, Bozeman..		16.4	15.58	82.5	20.0
3426.	Experiment Station, Bozeman..		18.7	17.78	89.9	16.2
3427.	C. H. McDonald, Belgrade.....		13.7	13.01	79.7	33.5
3428.	C. H. McDonald, Belgrade.....		18.0	17.1	85.8	15.3
3429.	Experiment Station, Bozeman..		18.8	17.86	87.5	9.4
3435.	Manhattan Co., Manhattan...		16.5	16.68	88.75	23.5
3447.	Wm. Flannery, Bozeman.....		18.9	17.96	89.2	22.3
3448.	Wm. Flannery, Bozeman.....		19.5	18.5	87.2	19.6
3449.	Wm. Flannery, Bozeman.....		21.3	20.2	93.7	21.6
3454.	E. D. Ferguson, Bozeman.....		12.5	11.9	72.7	72.0
3455.	E. D. Ferguson, Bozeman.....		18.4	17.5	87.5	22.3
3456.	F. W. Vreeland, Bozeman.....		16.8	15.96	86.5	18.1
3457.	E. D. Ferguson, Bozeman.....		17.2	16.3	86.0	30.0
3473.	T. Trent, Bozeman.....		13.8	13.1	78.0	23.8
Average.....			16.9	16.1	84.05	29.6

As a matter of further interest to the Gallatin Valley farmer, I also include a report, compiled by Prof. Burke, meteorologist of this station, giving the minimum temperature, during the last twenty-six years, for the month of October:

Year.	Date	Temp'ure	Year.	Date	Temp'ure
1880	30	10	1893	11	19
1881	12	0	1894	7	9
1882	18	16	1895	22 27	18
1883	11. 24	14	1896	30	24
1884	29	18	1897	15	19
1885	12 31	22	1898	3	19
1886	24 25	21	1899	13	4
1887	28	4	1900	23 31	22
1888	27	16	1901	12 29 30	30
1889	29	20	1902	30	23
1890	11	20	1903	30	22
1891	2	17	1904	18	20
1892	17 20	23	1905	18 19	8

SUGAR BEET SEED.

The work of the two previous years in testing beet seed raised in America in comparison with strains of seed raised abroad and shipped to America, has been continued. Seed of the Breustedt type, shipped direct from the growers in Germany, were sent to different parts of the state and they were grown, in many instances, side by side with the American seed grown under the supervision of the United States Department of Agriculture by H. E. Morrison of Fairfield, Washington. That the good character of the government seed, as given in my last annual report, has again been sustained, is shown by a comparison of the following figures, viz:

Table Showing Comparative Results From European and American beet seed

Variety	No. Samples analyzed ...	Sugar in Juice	Sugar in Beets	Purity Coef.	Average Wt. in ozs...
Aderstedt No. 2765	5	14.9	14.2	81.3	24.5
Breustedt's Elite No. 3084	12	15.2	14.4	80.3	24.8
Breustedt's Elite A No. 3085	4	16.3	15.5	82.5	25.4
Morrison's Government Seed	37	16.3	15.48	83.7	28.6
Breustedt's Neuere Zucht No. 3086..	3	14.8	14.1	82.0	31.0
Breustedt's Elite. from Bozeman's sugar Beet Committee	3	17.2	16.3	86.4	27.3
Knauer's Kleinwanzlebener No. 3081.	2	18.4	17.5	85.2	21.2
Knauer's Mangold No. 3080	2	14.8	14.05	78.05	34.8

The results of the two preceding years and the general excellence of Montana beets, taken into consideration together with the great advantages which certain parts of the state seem to offer to a new seed industry, have lead to a co-operative investigation with the Bureau of Plant Industry of the U. S. Department of Agriculture the object of which is to see if we can not produce beet seed in this state which will be more suitable to our local conditions, especially for dry land farming, than is the European seed. Expensive apparatus has been procured from Germany and a small number of beets, carefully selected from last year's crop, were siloed to keep them in a good, vigorous sprouting condition until next spring when each beet will be separately analyzed, tagged and planted, so that the history of each individual may be traced to the seed.

METEOROLOGICAL DIVISION.

EDMUND BURKE, *Meteorologist*.

The Eleventh and Twelfth Annual Reports of this Station contain a monthly and yearly summary of temperature, precipitation, character of day, and prevailing wind direction from November, 1903 to October, 1905 inclusive. The Twelfth Annual Report defines the location and gives a description of the meteorological apparatus used.

During the past year a record has been kept of the temperature, precipitation, humidity, soil temperatures, wind velocity, wind direction, hours sunshine, and character of day.

This Station has no complete meteorological data dating back further than January 1, 1900. It has been thought best to give in this report a monthly and yearly summary like, and including those in the Eleventh and Twelfth Annual Reports from January 1, 1900 to December 31, 1906.

TABLE II. WEATHER RECORD—SUMMARY BY MONTHS. (Cont.)

Months	Years	Highest Temperature.	Lowest Temperature.	Mean Temperature.	Precipitation	Snowfall	Clear Days	Partly Cloudy Days	Cloudy Days	Days with .01 inch or more Precipit'n	Prevailing Wind Direction
January.....	1903	50	—2	26.2	.78	10.4	7	15	9	5	
February	1903	44	—12	18.3	.33	4.0	15	10	3	3	
March... ..	1903	60	0	27.6	.67	6.6	5	24	2	6	
April	1903	69	4	37.8	3.42	21.0	7	17	6	6	SE.
May	1903	82	21	47.1	2.58	2.5	8	17	6	15	SW.
June	1903	82	39	59.5	2.45		12	14	4	11	SE.
July.....	1903	85	33	59.3	2.76		7	19	5	10	SE.
August	1903	91	39	63.1	.50		12	18	1	5	SE.
September	1903	81	28	50.4	1.11		9	18	3	8	SE.
October	1903	75	22	47.5	.76		15	14	2	4	SE.
November	1903	67	23	27.1	1.77	16.3	6	15	9	9	SE.
December	1903	54	3	25.2	.78	7.8	7	19	5	6	SE.
January	1904	48	4	22.5	.85	8.5	3	21	7	7	SW.
February	1904	49	—12	22.4	2.25	22.5	4	21	4	8	SE.
March.....	1904	50	—20	25.	2.98	2.8	7	22	2	11	SE.
April	1904	72	16	41.9	1.36	5.6	12	16	2	8	SE.
May	1904	74	28	48.2	2.02	4.4	5	21	5	10	SW.
June.....	1904	84	32	55.1	1.74	1.8	9	20	1	12	SW.
July.....	1904	88	36	62.1	1.11		10	21	0	7	SE.
August	1904	89	34	63.6	.86		12	19	0	6	SE.
September	1904	88	27	54.7	.06		15	13	2	1	SE.
October ..	1904	75	20	46.2	.56		13	16	2	4	SE.
November	1904	60	—16	35.13	.37	2.6	8	20	2	3	SE.
December	1904	50	—10	25.9	2.30	20.3	6	22	3	8	SW.

TABLE IV—WEATHER RECORD

Years	1900	1901
Highest Temperature	35 June 21 & July 31	97 July 31
Lowest Temperature	—24 Feb. 16	—14 Jan. 1
Greatest range for the year	119	111
Highest monthly mean	63.6 June	68.3 July
Lowest monthly mean	20.6 Feb	20.3 Feb.
Highest daily mean	79.5 June 21	77.5 July 21
Lowest daily mean	—16 Feb. 15	—15 Jan. 4
Mean temperature for the year	44	42.8
Greatest total precipitation for one mo.	3.05 June	4.95 May
Least total precipitations for one mo..	0 Nov.	.12 July
Total rainfall	13.77	15.29
Total snowfall	32.2	57.6
First killing frost	Sept. 24	Sept. 5
Last killing frost	May 13	June 5
Number of clear days in the year		
Number of cloudy days in the year..		
Number of partly cloudy days in year.		
Days with .01 inch or more of preci'tn	53	85

TABLE III. WEATHER RECORD.—SUMMARY BY MONTHS. (Cont.)

Months and Years	Highest Temperature	Lowest Temperature	Mean Temperature	Precipitation	Snow Fall	Clear Days	Partiy Cloudy Days	Cloudy Days	Days with .01 in. or more precip-tn	Prevalling Wind Direction
January 1905	48	—12	20.8	.23	2.3	6	18	7	3	SE.
February 1905	56	—33	20.8	.75	4.0	17	10	1	5	SE.
March 1905	60	—8	35.7	.77	5.4	7	20	4	8	SW.
April 1905	71	—18	40.4	.80	3.0	7	21	2	7	SE.
May 1905	71	26	45.2	3.23	2.0	4	23	4	16	E.
June 1905	78	33	52.8	2.62	0	3	22	5	14	SW.
July 1905	88	42	63.3	.74	0	11	20	0	8	SE.
August 1905	91	34	64.3	1.21	0	6	25	0	5	SE.
September 1905	84	30	57.2	1.48	3.0	12	16	2	2	SE.
October 1905	78	8	38.6	1.13	6.6	9	14	8	9	SE.
November 1905	68	—14	31.4	.70	9.8	7	12	11	4	SE.
December 1906	41	2	22.9	.33	5.6	6	23	2	4	SE.
January 1906	50	—4	25.1	.74	10.7	7	20	4	4	SW.
February 1906	48	—4	25.9	.73	9.6	9	15	4	6	SE.
March 1906..	60	—22	22	.92	2.3	8	20	3	8	SE.
April 1906	75	12	42.4	1.61	4.45	8	20	2	8	SE.
May 1906	80	24	47.7	2.34	1.25	2	26	3	14	NW.
June 1906	85	30	53.0	3.39	0	1	26	3	13	NW.
July 1906	89	41	65.4	.49	0	14	17	0	5	SE.
August 1906	92	38	61.6	3.59	0	7	14	10	13	NE.
September 1906	82	29	55.6	1.38	0	14	13	3	4	SE.
October 1906	76	17	45.5	1.35	2.0	10	20	1	8	SE.
November 1906	61	—3	28.0	1.70	14.0	8	19	3	14	SW.
December 1906.....	49	0	28.2	.43	6.6	6	17	8	3	SE.

SUMMARY BY YEARS

1902	1903	1904	1905	1906
86 July 13 & 21	91. Aug 19	89 Aug. 14	91 Aug. 24	92 Aug. 16
—28 Jan. 26	—23 Nov. 17	—20 Mar. 25	—33 Feb. 11	—22 Mar. 15
114	114	109	124	114
61.4 Aug.	63.1 Aug.	63.6 Aug.	64.3 Aug.	6.54 July
20.2 Jan.	18.3 Feb.	22.4 Feb.	16.8 Feb.	22.0 Mar.
73.5 Aug. 25	73.5 Aug. 15	71.5 Aug. 14	75 Aug. 24	75.5 July 22
—17.5 Jan 25.	—11 Nov. 17	—7.5 Mar. 25	—24.5 Feb. 11	—11 Mar. 15
41.8	40.8	42.2	40.8	41.77
3.90 May	3.42 April	2.98 March	3.23 May	3.39 June
.20 Oct.	.33 Feb.	.06 Sept.	.23 Jan.	.43 Dec.
15.64	17.91	16.46	13.99	18.67
42.7	68.6	68.5	41.7	48.8
Sept. 6	Sept 11	Sept. 13	Sept. 18	Sept 12
June 20	May 24	June 25	May 12	June 8
98	110	104	95	94
66	54	30	46	44
201	201	232	224	227
87	86	85	85	100

HORTICULTURAL DEPARTMENT.

R. W. FISHER, *Horticulturist*.

From the Horticultural Department the following report is presented, giving the results of work carried on during the year that may be of immediate value to the people of the state. Observations along these lines will be continued and the results of several years' tests averaged and presented together.

THINNING FRUIT.

In order to determine the relative value of thinning the fruit on apple trees, it is necessary to thin the fruit on a given number of trees and leave other trees, growing under the same conditions, unthinned. Because of a uniformly light crop of apples throughout the Bitter Root Valley this year, it was hard to find an orchard in which there were sufficient number of well loaded trees to carry on the work. Experiments, however, were conducted in the orchards of Mr. D. C. Bass near Stevensville and Mr. Henry Buck of Stevensville. We determined the relative cost of thinning but the results did not show a very material increase in the size of the apples, no doubt, because of the fact that none of the trees in either orchard were carrying a very heavy crop. In the orchard of Mr. Buck the cost of thinning the fruit on Wealthy trees, 12 years old and from 3½ to 4½ inches in diameter and 12 to 20 feet in height, was 2 1-3 cents per tree, or \$2.52 per acre. As previously stated the trees were not very heavily loaded, thus explaining the comparatively small cost in thinning. When the apples were harvested there was apparently no difference in the size or color of the fruit from thinned and unthinned trees.

The cost of thinning the fruit in the orchard of Mr. Bass was 4 2-3 cents per tree, or \$5.40 per acre. The trees in this orchard were larger and were producing a heavier crop than the trees in Mr. Buck's orchard. As nearly as can be determined, the thinning in this orchard increased the size about 10 per cent and on trees very heavily loaded the thinning made the fruit of a marketable size, where otherwise it would have been too small.

The Wealthy is characterized by producing very large crops, and unless the fruit is thinned, a large percentage is often too small for market.

Thinning also has the beneficial effect of preventing the trees from breaking down as a result of over bearing. While we have been unable to get accurate data in regard to the beneficial effects of thinning, yet the experiments indicate that the percentage of marketable apples can be materially increased by thorough thinning and that the trees can, to a certain extent, be prevented from breaking down. The experiments thus far conducted also indicate that the fruit should be thinned as early in the spring as danger from frosts is over. In this connection the experience of Mr. Fred Whiteside of Kalispell in thinning fruit is of interest to fruit growers. Mr. Whiteside has found that after a large proportion of the fruits on Wealthy, Wagoner and other varieties had been picked off, early in the season, about the time the fruit is well formed and the size of a hazelnut, the apples on the thinned trees, at the time of harvesting would equal and in some instances exceed in weight the apples on unthinned trees with not more than 1-2 to 3-4 as many fruits.

The experiments thus far conducted by this department and from experience of fruit growers throughout the state, point to the following conclusions:

1st. It pays to thin the apples on trees which are heavily loaded.

2d. Thinning increases the size without decreasing the total weight.

4d. Thinning often prevents limbs from breaking down, by distributing the fruit over the tree.

4th. Thinning should be done early in the season, before the fruit has started to grow and the seeds have formed. The experience of many successful fruit growers has determined that it is best to thin when danger of severe frosts has passed and before the fruit has grown larger than a hazel-nut. To make the results more effective, however, thinning should be done more or less throughout the growing season.

VARIETY AND CULTURAL TESTS WITH VEGETABLES.

Montana imports an enormous quantity of vegetables which could as well be grown by the farmers of Montana. Several years ago this department started tests of the commercial varieties of common garden vegetables in order to ascertain the varieties best adapted to our conditions and the methods best to pursue in growing. In this report results for year ending Nov. 30, 1906, are given.

TABLE I—DATES OF PICKING AND

Variety	First Picking		Sec. Picking		Third Picking	
	Date	Wt.	Date	Wt.	Date	Wt.
Keeny's Rustless Golden Wax	Aug. 17	4 oz.	Aug. 21	16 oz.	Aug. 30	16 oz.
The Goddard	Aug. 17	20 oz.	Aug. 21	32 oz.	Aug. 30	20 oz.
Long Yellow Six Weeks	Aug. 14	32 oz.	Aug. 17	34 oz.	Aug. 21	16 oz.
Early Red Valentine	Aug. 14	7 oz.	Aug. 17	22 oz.	Aug. 21	16 oz.
Perfection Wax	Aug. 14	14 oz.	Aug. 17	21 oz.	Aug. 21	10 oz.
Best of All	Aug. 14	7 oz.	Aug. 17	15 oz.	Aug. 21	9 oz.
Early Mohawk	Aug. 14	19 oz.	Aug. 17	11 oz.	Aug. 21	13 oz.
Golden Wax	Aug. 14	24 oz.	Aug. 17	17 oz.	Aug. 21	13 oz.
Davis Dwarf White Wax	Aug. 14	6 oz.	Aug. 17	8 oz.	Aug. 24	8 oz.
Golden Eyed Wax	Aug. 14	6 oz.	Aug. 17	16 oz.	Aug. 24	14 oz.
Longfellow	Aug. 14	16 oz.	Aug. 17	24 oz.	Aug. 24	11 oz.
Davis Wax	Aug. 14	17 oz.	Aug. 17	14 oz.	Aug. 24	16 oz.
Brittle Wax	Aug. 14	9 oz.	Aug. 17	9 oz.	Aug. 24	8 oz.
Dwarf German Black Wax...	Aug. 14	19 oz.	Aug. 17	9 oz.	Aug. 24	12 oz.
White Seeded Wax	Aug. 14	5 oz.	Aug. 17	18 oz.	Aug. 24	22 oz.
Extra Early Refugee	Aug. 14	15 oz.	Aug. 17	16 oz.	Aug. 24	14 oz.
Crystal White Wax	Aug. 17	2 oz.	Aug. 24	9 oz.	Aug. 30	7 oz.
Wardwell's Kidney Wax	Aug. 14	21 oz.	Aug. 17	9 oz.	Aug. 24	9 oz.
Early Great Northern	Aug. 14	7 oz.	Aug. 17	6 oz.	Aug. 21	5 oz.
Early Navy	Aug. 17	5 oz.	Aug. 21	12 oz.	Aug. 30	9 oz.
Currie's Rust-proof Gld'n wax	Aug. 14	22 oz.	Aug. 17	8 oz.	Aug. 21	5 oz.
New Giant Stringless	Aug. 14	4 oz.	Aug. 17	3 oz.	Aug. 21	2 oz.
Large White Kidney	Aug. 14	7 oz.	Aug. 17	7 oz.	Aug. 21	7 oz.
Black Valentine	Aug. 14	16 oz.	Aug. 17	6 oz.	Aug. 21	5 oz.
Cream Valentine	Aug. 14	10 oz.	Aug. 17	17 oz.	Aug. 21	12 oz.
Imp'd. Rust-proof Golden wax	Aug. 14	23 oz.	Aug. 17	8 oz.	Aug. 21	10 oz.
Bountiful	Aug. 14	38 oz.	Aug. 17	11 oz.	Aug. 21	8 oz.
China Red Eye	Aug. 14	26 oz.	Aug. 17	6 oz.	Aug. 21	6 oz.
Dwarf Horticultural	Aug. 14	24 oz.	Aug. 17	10 oz.	Aug. 21	3 oz.
Early Warwick	Aug. 14	42 oz.	Aug. 17	13 oz.	Aug. 21	2 oz.
Red Valentine	Aug. 14	14 oz.	Aug. 17	16 oz.	Aug. 21	13 oz.
White Marrow	Aug. 14	2 oz.	Aug. 17	7 oz.	Aug. 21	9 oz.
Black Wax	Aug. 14	7 oz.	Aug. 17	11 oz.	Aug. 21	3 oz.
New Stringless	Aug. 14	18 oz.	Aug. 17	9 oz.	Aug. 21	2 oz.
Flageolet	Aug. 14	24 oz.	Aug. 17	21 oz.	Aug. 21	6 oz.
Pencil Pod	Aug. 14	5 oz.	Aug. 17	11 oz.	Aug. 21	6 oz.
German Wax	Aug. 14	10 oz.	Aug. 17	9 oz.	Aug. 21	4 oz.
Golden Wax	Aug. 14	8 oz.	Aug. 17	10 oz.	Aug. 21	22 oz.
Valentine Wax	Aug. 14	24 oz.	Aug. 17	6 oz.	Aug. 21	6 oz.
Jones Stringless	Aug. 17	2 oz.	Aug. 21	10 oz.	Aug. 30	13 oz.
Round Yellow Six Weeks..	Aug. 14	10 oz.	Aug. 17	21 oz.	Aug. 21	22 oz.
White Marrowfat	Aug. 17	2 oz.	Aug. 21	14 oz.	Aug. 30	11 oz.

BEANS.

In the following table the varieties grown, the yield of each variety and date of picking are given, with the total weight picked, and notes on the quality of each variety. In this test (10) ten feet of each variety were taken. The plants were about 4 inches apart in the row, thus making approximately (30) thirty plants of each variety tested.

WEIGHT OF CROP OF BEANS FOR SEASON OF 1906

Fourth Picking		Fifth Picking		Total No.	Color of Pod	Quality
Date	Wt.	Date	Wt.			
Sept. 19	52 oz.	Sept. 19		88	Yellow	Good
Sept. 19	44 oz.	Sept. 19		110	Green	Fair
Aug. 30	8 oz.	Sept. 19	32 oz.	122	Green	Very Good
Aug. 30	6 oz.	Sept. 19	44 oz.	95	Green	Good
Aug. 30	5 oz.	Sept. 19	48 oz.	98	Cream	Good
Aug. 30	13 oz.	Sept. 19	40 oz.	84	Green Spotted	Fair
Aug. 30	11 oz.	Sept. 19	56 oz.	110	Green	Fair
Aug. 30	25 oz.	Sept. 19	37 1-3oz.	116	Golden	Good
Aug. 30	6 oz.	Sept. 19	28 oz.	56	Cream	Fair
Aug. 30	6 oz.	Sept. 19	32 oz.	74	Cream	Poor, Stringy
Aug. 30	8 oz.	Sept. 19	40 oz.	99	Green	Very Good
Aug. 30	8 oz.	Sept. 19	28 oz.	85	Golden	Fair
Aug. 30	4 oz.	Sept. 19	14 oz.	44	Golden	Good
Aug. 30	6 oz.	Sept. 19	24 oz.	70	Golden	Good
Aug. 30	6 oz.	Sept. 19	16 oz.	67	Cream	Good
Aug. 30	13 oz.	Sept. 19	40 oz.	98	Green	Good
Sept. 19	64 oz.	Sept. 19	24 oz.	82	Green	Good
Aug. 30	4 oz.	Sept. 19	24 oz.	67	Golden	Good
Aug. 30	8 oz.	Sept. 19	30 oz.	56	Golden	Poor, Stringy
Sept. 19	32 oz.			58	Green	Poor, Stringy
Aug. 30	6 oz.	Sept. 19	6 oz.	47	Golden	Fair
Aug. 30	5 oz.	Sept. 19	31 oz.	45	Green	Good
Aug. 30	6 oz.	Sept. 19	38 oz.	65	Green	Poor, Stringy
Aug. 30	6 oz.	Sept. 19	19 oz.	52	Green	Good
Aug. 30	7 oz.	Sept. 19	48 oz.	94	Green	Good
Aug. 30	7 oz.	Sept. 19	32 oz.	80	Golden	Good
Aug. 30	4 oz.	Sept. 19	16 oz.	77	Green	Poor, Stringy
Aug. 30	5 oz.	Sept. 19	15 oz.	53	Green	Fair
Aug. 30	6 oz.	Sept. 19	6 oz.	49	Green Spotted	Fair
Aug. 30	5 oz.	Sept. 19	6 oz.	68	Green	Poor, Stringy
Aug. 30	8 oz.	Sept. 19	37 oz.	88	Green	Good
Aug. 30	20 oz.	Sept. 19	56 oz.	94	Green	Good
Aug. 30	9 oz.	Sept. 19	29 oz.	59	Cream	Good
Aug. 30	3 oz.	Sept. 19	9 oz.	41	Green	Good
Aug. 30	8 oz.	Sept. 19	22 oz.	81	Golden	Good
Aug. 30	5 oz.	Sept. 19	8 oz.	35	Cream	Good
Aug. 30	4 oz.	Sept. 19	16 oz.	43	Golden	Good
Aug. 30	4 oz.	Sept. 19	13 oz.	57	Golden	Good
Aug. 30	9 oz.	Sept. 19	15 oz.	60	Cream	Very Good
Sept. 19	64 oz.			89	Green	Fair
Aug. 30	13 oz.	Sept. 19	44 oz.	110	Green	Good
Sept. 19	60 oz.			87	Green	Fair

From the table it may be seen that Long Yellow Six Weeks, the Goddard, Early Mohawk and Golden Wax produced comparatively the largest yields of snap beans. The varieties of best quality of the green snap beans, regardless of yield, were,—Long Yellow Six Weeks and Longfellow; of the Yellow or wax snap beans the Valentine wax and the Keeny's Rustless Golden wax were best in quality. The Early Warwick was the earliest variety tested, producing the first snap beans.

The following varieties did not mature seeds:—Early Great Northern, White Navy, Crystal White, White Seeded wax, Burpee's Perfection wax, Keeny's Rustless Golden wax, White Marrow fat and Jones Stringless.

CABBAGE.

The following varieties of cabbages were grown in the experimental garden to determine the largest yielding varieties and the ones best adapted for commercial purposes.

The seed was planted in flats in the greenhouse April 20th and the plants transplanted into the open ground June 1st. All varieties were planted 2x3 feet apart, or at the rate 7260 plants per acre.

The following table gives the percent of each variety forming heads, the average weight of the heads of each variety and the yield per acre; computed by multiplying the average weight per head by the number of plants per acre.

About 1-72 of an acre of each variety was grown. The notes indicate the quality and condition of each variety at the time of harvesting.

TABLE II—RECORD OF THE CABBAGE GROWN FOR SEASON OF 1906

Variety of Cabbage	Per cent good	Avg. wt. per head ..	Yield in lbs. per acre	Notes
Acme Flat Dutch	97	7.306	53041	Quality good; solid.
Short Stemmed Drumhead ..	98	4.158	30187	Heads medium solid
All Head Early	91	7.875	57172	Heads solid; condition good
Early Stone head	98	3.56	25845	Heads small; not very solid
Burpee's Safe Crop	80	4.083	29642	Heads not solid.
Holland	79	6.088	44198	Heads not solid; condition and quality poor
Small Savoy	50			No good
Mid-summer	100	5.488	39842	Heads medium solid
Premium Flat Dutch	80	6.029	43770	Heads medium solid.
Mammoth Rock Red	83	3.78	27442	Heads small, solid; Color red
Early June	86	3.58	25990	Solid; quality good
Autumn King	91	4.809	34913	Solid; good.
Green Glazed American				Did not mature
Sure Head	84	3.842	27892	Not very solid
Extra Early Express	100	5.522	40089	Not very solid; condition fair.
Large Red Drumhead	86	5.432	39536	Solid. good; red color
Fielderkraut	83	4.725	34303	Not solid; condition poor.
Late Stonehead	99	5.629	40866	Solid; condition good
Perfection Drumhead Savoy..	72	3.578	25976	Those forming heads solid and good quality.
Harvest Home	90	6.413	46558	Solid, good condition.
Danish Roundhead	100	7.	50820	Solid, condition good.
Danish Baldhead	92	7.305	53054	Solid, condition good
Succession	94	6.09	44213	Solid, condition good

The varieties producing the largest yield of good quality, solid heads, of late keeping, were,—Acme Flat Dutch, Danish Round Head, Danish Ball Head and Succession.

TOMATOES.

Ten varieties of early tomatoes were grown in the experimental garden this season. The seeds were sown in the greenhouse bench March 23, transplanted into flats April 8th and put into pots May 5th to May 20th, from which they were transplanted into the open ground June 11th after danger of severe frosts had passed.

Seventy plants of each variety were set out, four feet apart, on ground that has not been manured for four years. The first thirty-five plants of each variety were trimmed to a single stem and tied to a stake. The second thirty-five plants of each variety were not pruned at all. Both plots were irrigated and cultivated in the same way, receiving an abundance of water and cultivation until July 15th, when both irrigation and cultivation were stopped.

The table indicates the varieties ripening the first fruits, and the amount of both ripe and green tomatoes produced during the season on the plants pruned and not pruned.

Burpee's Earliest Pink produced the largest amount of ripe fruit before the plants were killed by frost. With but two exceptions, the plants pruned to one stem produced a much larger amount of ripe tomatoes than the plants not pruned. The varieties yielding the largest amount of ripe tomatoes of good quality were,—Spark's Earliana, Earlibell and Burpee's Earliest Pink. These varieties also ripened the first fruits.

For early tomatoes of good quality in the high altitudes of the state we would recommend planting seeds of Spark's Earliana, Earlibell, or Earliest Pink in March or early in April and transplanting into pots. They should be set out as soon as danger of killing frosts have passed and the plants pruned to one stem and tied to a stake. There was a difference of twenty-two days in ripening between the earliest variety on the pruned and unpruned plots, thus indicating that pruning and staking the plants has a very material influence upon early ripening.

TABLE III—RECORD OF TOMATOES GROWN SEASON OF 1906

Variety of Tomatoes	Pruned to One Stem				Notes
	Date 1st ripe	Amt. ripe Sept. 1	Total Amt. ripe	Total Amt. green	
Matchless	Sept. 8	19	68	37	Color of fruit, dark red; smooth
Dwarf Golden Champion	Aug. 26	19	57	11	Color of fruit, purplish red; smooth
Climax	Sept. 1	4	107	32	Color of fruit, purplish red; ½ smooth
Tucker's Favorite	Sept. 6		62	51	Color of fruit, light red; smooth
Burpee's Earliest Pink	Aug. 26	48	175	46	Color of fruit, pink; rough
Bolghano's Early Prolific I. X. L.	Sept. 1	16	123	25	Color of fruit, dark red; ¾ smooth
Acme.....	Aug. 26	8	115	41	Color of fruit, dark red; smooth
Earlibell.....	Aug. 24	18	141	48	Color of fruit, dark red; ½ smooth
Sparks Earlianna	Aug. 23	32	149	29	Color of fruit, light red; ¾ smooth
Greater Baltimore	Sept. 1	10	115	44	Color of fruit, dark red; smooth

Variety of Tomatoes	Not Pruned				Notes
	Date 1st ripe	Total Amt. ripe	Total Amt. green		
Matchless	Sept. 29.	29	167	¾	Color of fruit, dark red; smooth
Dwarf Golden Champion	Sept. 14	24	9	½	Color of fruit, purplish red; smooth
Climax	Sept. 29	24	195	¾	Color of fruit, purplish red; ½ smooth
Tucker's Favorite	Oct. 6	4	148	½	Color of fruit, light red; smooth
Burpee's Earliest Pink	Sept. 14	203	390		Color of fruit, pink; rough
Bolghano's Early Prolific I. X. L.	Sept. 14	194	313	½	Color of fruit, dark red; ¾ smooth
Acme.....	Sept. 24	51	200		Color of fruit, dark red; smooth
Earlibell.....	Sept. 13	98	156		Color of fruit, dark red; ½ smooth
Sparks Earlianna	Sept. 14	143	387		Color of fruit, light red; ¾ smooth
Greater Baltimore	Oct. 6	24	197		Color of fruit, dark red; smooth

ONIONS.

Seeds of Yellow Globe Danvers, Prize Taker, Extra Early Red, Australian Brown and Large Red Wethersfield onions were sown in the greenhouse bench March 19th. On May 15th, when the bulbs were about one-sixteenth of an inch in diameter they were transplanted to the open ground; one-fifth of an acre of each variety being planted.

From tests in small plots made in previous years of transplanting onions, a very large yield of good mature onions has been secured, and the object of the experiment this year of transplanting one-fifth of an acre of the five best varieties of previous years, was to determine what could be accomplished in growing onions on a commercial basis.

The cost of growing the seedlings in a hot-bed, preparing the ground, transplanting, cultivating and irrigating the onions was, approximately, \$50.00 per acre.

In an ordinary year, as shown by the results obtained during the past three years in growing onions by the transplanting method in small plots, the yield would have been in the neighborhood of 60,000 pounds per acre. At \$.01 per pound this would make \$600.00 approximately, \$50.00 per acre.

The onions were larger and thriftier when transplanted than in any previous year but because of unfavorable weather conditions during June and July the plants made practically no growth, and not more than one-tenth of the bulbs matured. In a favorable season onion growing by the transplanting method is very profitable, as a very large yield can be obtained, and they may be sold at a reasonably good price.

ORNAMENTAL TREES AND SHRUBS.

New and promising kinds of ornamental trees and shrubs are being planted in the trial nursery each year. These plants are procured from various sources; many of them are grown from seed at the Station, others are sent us by the U. S. Department of Agriculture and various State Experiment Stations, some good kinds have been sent us from foreign countries but most of the plants now growing on the Station grounds have been purchased from nurseries throughout the United States. Several very good kinds of ornamental shrubs have been brought in from the moun-

tains of Montana and we are now looking to our native flora for the best plants to grow upon our lawns.

Because of the high altitudes and short growing season in many parts of Montana, it is hard to grow many of the plants that have proven hardy in other northern states.

From experience in growing plants here for five years, it seems that some conditions other than extreme cold in winter is the cause of so many hardy plants, of other states, being killed. The cause has been attributed to the short growing season, early fall frosts, and the alternate freezing and thawing during the spring months.

The plants that have been growing in the trial nursery for more than one year are here given, with notes on the growth of each kind.

From the table it may be seen that the plants which have been hardy in the trial nursery are:

Box Elder	Sand Cherry
Tatarian Maple	Choke Cherry
Service Berry	Siberian Crab
June Berry	Burr Oak
White Birch	Yellow-flowering Currant
Siberian Pea Tree	Wild Roses
Scarlet Shorn	Laurel Leaf Willow
Gold-leaf Privet	Mountain Ash
American Aspen	Lilacs in variety
Cottonwood	Arrow-wood
Bolles' Poplar	Conifers

There are a number of very beautiful plants given in the above table as half-hardy or even tender that may be grown when given protection during the winter. Many of the plants marked as half-hardy do not kill back enough to seriously interfere with subsequent growth or blooming, and may successfully be grown upon the lawn without extra winter protection; such plants are some of the Spiraeas, Barberries, etc.

TABLE IV.—ORNAMENTAL TREES AND SHRUBS.

Scientific Name	Notes on Hardiness
<i>Acer saccharinum</i>	Silver Maple
<i>Acer saccharinum</i> Van Wiewi ..	Wier's Maple
<i>Acer platanoides</i>	Norway Maple
<i>Acer saccharum</i>	Sugar Maple
<i>Acer Negundo</i>	Box Elder
<i>Acer Tataricum</i>	Tatarian Maple
<i>Amelanchier Alnifolia</i>	Service Berry
<i>Amelanchier Botryopium</i>	Half-Dwarf Juneberry
<i>Amelanchier Botryopium</i>	Dwarf Juneberry
<i>Ampelopsis quinquefolia</i>	Virginia Creeper
<i>Ampelopsis Englemanni</i>	Virginia Creeper
<i>Berberis vulgaris</i>	Common Barberry
<i>Berberis Vulgaris</i> , Var <i>atropurpurea</i> .	Purple leaved barberry
<i>Berberis Thunbergii</i>	Thunberg's Barberry
<i>Petula alba</i>	European White Birch
<i>Caragana arborescens</i>	Siberian Pea Tree
<i>Caragana frutescens</i>	Pea Tree
<i>Catalpa speciosa</i>	Hardy Catalpa
<i>Cercis canadensis</i>	Red Bud
<i>Cercis canadensis</i> , var—	White Red Bud
<i>Chionanthus Virginica</i>	White Fringe
<i>Crataegus coccinea</i>	Scarlet Thorn
<i>Crataegus Crus-galli</i>	Cock-Spur Thorn
<i>Deutzia Lemoinel</i>	Deutzia
<i>Deutzia scabra</i> , var <i>plena</i>	Deutzia, dll. flower
<i>Diospyros Virginiana</i>	Common Persimmon
<i>Euonymus Europaeus</i>	European Burning Bush
<i>Fagus ferruginea</i>	American Beech
<i>Fraxinus Americana</i>	White Ash
<i>Fraxinus Penn'lvania</i> var. <i>lanceolata</i> .	Green Ash
<i>Hibiscus Syriacus</i>	Shrubby Althea
<i>Hicoria Pecan</i>	Pecan
<i>Hydrangea paniculata</i>	Hardy hydrangea
<i>Juglans nigra</i>	Black Walnut
<i>Laburnum Alpium</i>	Scotch Laburnum
	Top Kills back; half hardy.
	Top Kills back; half hardy.
	Kills but very little; prom. to be hardy
	Tender.
	Hardy; good for general planting
	Hardy; good shrub for hardy border
	Hardy; good shrub for hardy border
	Hardy; similar to above.
	Hardy; similar to above.
	Hardy when given some protection.
	Hardy; when given some protection.
	Al'mst hdy.; don't kill eno'h to injure
	Al'mst hdy.; don't kill eno'h to injure
	Al'mst hdy.; don't kill eno'h to injure
	Hardy; good for lawn specimens.
	Hardy; good for hardy border or hedge
	Hardy.
	Tender.
	Tender.
	Tender.
	Tender.
	Hardy; has not killed in 3 winters.
	Tender.
	Tender.
	Tender.
	Tender.
	Half. h'dy.; don't kill enough to injure.
	Tender.
	Young trees tender; old trees hardy.
	Young trees tender; old trees hardy.
	Tender.
	Tender.
	Tender unless protected.
	Nearly hardy; foliage tender.
	Nearly hardy.

TABLE IV.—ORNAMENTAL TREES AND SHRUBS. (Continued.)

Scientific Name	Common Name.	Notes on Hardiness
<i>Larix decidua</i>	European Larch	Hardy
<i>Ligustrum ovalifolium</i>	California Privet	Nearly hardy; seldom kills.
<i>Ligustrum vulgare, var-aureum</i>	Gold-leaved Privet	Hardy.
<i>Ligustrum vulgare var-variegatum</i>	Golden-Spotted Privet	Hardy.
<i>Lonicera Tatarica</i>	Tartarian Honeysuckle	Hardy shrub.
<i>Berberis Aquifolium</i>	Oregon	Hardy in sheltered place
<i>Morus alba, var. Tartaricum</i>	Russian	Tender.
<i>Philadelphus Coronarius</i>	Mock Orange	Half-hardy.
<i>Philadelphus Lemoinei</i>	Mock Orange	Half-hardy.
<i>Philadelphus Grandiflorus</i>	Mock Orange	Half-hardy.
<i>Populus betulifolia</i>	Canadian or Black Poplar	Hardy; promises well for shade trees.
<i>Populus deltoides, var-Carolinensis</i>	Carolina Poplar	Young trees hardy; tender when old.
<i>Populus laurifolia</i>	Certenensi Poplar	Nearly hardy.
<i>Populus tremuloides</i>	American Aspen	Hardy.
<i>Populus balsamifera</i>	Balsam Poplar or Cottonwood	Hardy; native.
<i>Populus Angustifolia</i>	Narrow-leaved Cottonwood	Hardy; native.
<i>Populus deltoides</i>	Cottonwood	Hardy; native.
<i>Populus alba, var.—Boll—Cana.</i>	Bolles' Poplar	Apparently hardy.
<i>Populus nigra, var.—Italica</i>	Lombardy Poplar	Tender.
<i>Prunus Amygdalus</i>	Double Flowering almond	Half-hardy; does well when protected.
<i>Prunus pissardi</i>	Purple-leaved Plum	Tender, unless protected.
<i>Prunus triloba</i>	Double-flowering Plum	Tender.
<i>Prunus pumila</i>	Sand Cherry	Hdy.; val. for foliage effect & screens.
<i>Prunus Virginiana</i>	Choke Cherry	Hdy.; val. for foliage effect & screens.
<i>Pyrus baccata</i>	Siberian Crab	Hdy.; val. for foliage effect & screens.
<i>Pyrus Japonica</i>	Japanese Quince	Tender, unless protected.
<i>Quercus Coccinea</i>	Scarlet Oak	Tender.
<i>Quercus macrocarpa</i>	Burr Oak	Hardy, slow growing.
<i>Quercus palustris</i>	Pin Oak	Half-hardy.
<i>Rhamnus Cathartica</i>	Buckthorn	Almost hardy; good for hedge.
<i>Rhus Cotinus</i>	Smoke Bush	Tender.
<i>Rhus Cotinoides</i>	Chittam-wood	Tender.
<i>Rhus typhina, var.—laciniata.</i>	Cut-leaf Staghorn Sumac	Half-hardy.
<i>Ribes aureum</i>	Yellow Flowering Currant	Hardy
<i>Rosa multiflora</i>	Wild Rose	Tender.

TABLE IV.—ORNAMENTAL TREES AND SHRUBS. (Continued.)

Scientific Name	Common Name	Notes on Hardiness
<i>Rosa rugosa</i> ..	Japanese Rose ..	Hardy; fine for foliage effect
<i>Rosa Carolina</i> ..	Wild Rose ..	Hardy.
<i>Salix alba</i> ..	White Willow ..	Hardy.
<i>Salix pentandra</i> ..	Laurel-leaf Willow ..	Hardy.
<i>Sambucus Canadensis</i> , var.— <i>aurea</i> ..	Golden Elder ..	Tender.
<i>Spiraea Reevesiana</i> ..	<i>Spiraea</i> ..	Tender.
<i>Spiraea Reevesiana</i> var. <i>flore plena</i> ..	Double <i>Spiraea</i> ..	Tender.
<i>Spiraea Thunbergii</i> ..	<i>Spiraea</i> ..	Almost hdy.; good for gen. planting.
<i>Sorbus arbutifolia</i> ..	Mountain Ash ..	Hardy.
<i>Sorbus aucuparia</i> ..	European Mt. Ash ..	Hardy; good lawn tree.
<i>Spiraea Van Houttei</i> ..	<i>Spiraea</i> ..	Almost hardy; very good for lawn.
<i>Syringa Vulgaris</i> , var. <i>alba</i> ..	White Lilac ..	Hardy; good for general planting.
<i>Syringa Vulgaris</i> , var. <i>purpurea</i> ..	Purple Lilac ..	Hardy; good for general planting.
<i>Syringa Japonica</i> ..	Japan Tree Lilac ..	Hardy; good for general planting.
<i>Syringa Chinensis</i> ..	Rothomagensis Lilac ..	Hardy; good for general planting.
<i>Tamarix parviflora</i> ..	<i>Tamarix</i> ..	Tender.
<i>Tamarix Gallica</i> ..	<i>Tamarix</i> ..	Tender.
<i>Tamarix juniperina</i> ..	<i>Tamarix</i> ..	Tender.
<i>Tilia Americana</i> ..	American Linden ..	Tender.
<i>Ulmus Americana</i> ..	American Elm ..	Not hdy, except on moist silt.. ground
<i>Viburnum dentatum</i> ..	Arrow Wood ..	Hardy.
<i>Viburnum opulus</i> , var. <i>Sterile</i> ..	Snow-ball ..	Half-hardy.
Coniferae ..	.....	.....
<i>Larix americana</i> ..	Tamarack or Larch ..	Hardy.
<i>Larix decidua</i> ..	European Larch ..	Hardy.
<i>Abies balsamea</i> ..	Balsam Fir ..	Hardy.
<i>Abies con-color</i> ..	White Fir ..	Hardy.
<i>Picea pungens</i> ..	Colorado Blue Spruce ..	Hardy.
<i>Pinus ponderosa</i> ..	Yellow Pine ..	Hardy.
<i>Pinus contorta</i> , var. <i>Murrayana</i> ..	Lodge Pole Pine ..	Hardy.
<i>Pinus sylvestris</i> ..	Scotch Pine ..	Hardy.
<i>Pinus Montana</i> , var. <i>Mughus</i> ..	Mountain Pine ..	Hardy.
<i>Pseudotsuga Mucronata</i> ..	Douglas Spruce ..	Hardy.
.....	Red Cedar ..	Almost Hardy.
.....	Arbor-vitae ..	Almost Hardy.

IRRIGATION DEPARTMENT.

E. TAPPAN TANNATT, *Engineer.*

The investigations of the Engineering Department have been carried on partly at the Experiment Station and partly over the state.

The investigations at the Experiment Station were; first, the observation of the amount of evaporation from water surface in a tank set level with the surface of the ground. This tank and equipment were the same as had been used in previous years. After continuing the investigations for a short time it was found that the tank was subject to the action of spray from a lawn sprinkling system which had been installed but a short time. It was found necessary to move the tank to another position. The difficulties above referred to prevented the securing of satisfactory records of evaporation covering the irrigation season.

Second: Drainage investigations were taken up at the Station with a view of studying ground water and seepage conditions, to design a working system of drains for the particular class of land, and to develop the ground waters for irrigation and experimental purposes. With this object in view, a system of wells were driven in the section referred to and the sub-strata examined. A system of drainage was then established and the former system removed. The results and plans of this work are fully described in bulletin No. 65.

In connection with this drainage system it was planned to make some studies of the practicability of pumping water for irrigation purposes. Accordingly, a double power windmill, donated by the manufacturers, was installed upon a forty foot tower and on the ground floor of this tower a gasoline engine and a pump were also put up, to be used in pumping the water. The water from the area drained was run into a large concrete lined sump, from which the water could be pumped to a flume and a storage reservoir. This plant was especially designed to permit of the study of the special seepage problems now being investigated by the department.

Early in the season the department took up with the Office of Public Roads at Washington, D. C. the question of constructing a model road. Through the efforts in this direction and the assistance of the city of Bozeman and Gallatin County, a half mile of road has been constructed along the north line of the Experiment Station farm. The character of the road, although not the best, was limited on account of funds available and thus the earth road form of construction was used.

For some years past, drainage investigations have been carried on by this department in the Yellowstone Valley near Billings. These investigations have been continued during the past season with a hope of finding some clue which would point to a satisfactory solution of the problem. The wells and well records established by the former Irrigation Engineer were examined and it was found that the openings in the iron castings had been so thoroughly silted as to render the resulting records, in a large measure, valueless. The plan of using casing in wells was abandoned and a system of drainage investigations conducted in connection with the I. D. O'Donnell and Arnold drains which are under construction. A recorder was kept on the work from June 1st to Nov. 20th and a careful system of records obtained. The results of these records have clearly demonstrated the inadvisability of depending solely upon the drain ditches as a solution of the problem presented. The records have clearly demonstrated the necessity of first investigating the seepage conditions of the big ditches with a view of stopping the same. The investigations have clearly proven the fallacy of attempting to satisfactorily drain the wet lands of the Yellowstone Valley until after more careful attention has been given to seepage conditions of the big ditches of the valley and the unnecessary waste of irrigation water. The quicksand sub-strata of this valley also brings up the question of the advisability of studying the best methods of draining the lands in question.

In connection with the seepage investigations conducted by the department, various parts of the state have been visited with a view of securing natural materials that might be used in controlling these seepage conditions. The investigations thus far have been satisfactory indeed, although we are not as yet in a position to give results.

During the year the Department has been called upon to visit

several sections of the state in order to settle disputes as to the proper methods of measuring water. The amount of ignorance manifested along this line has been surprising and we have concluded to publish a complete and definite bulletin upon the methods of measuring water. This bulletin is in process of preparation.

The progress of the investigations at the Station has demonstrated the advisability of continuing the drainage and seepage experiments as originally contemplated, keeping in mind the securing of a cementing material which will prevent seepage. The plant as now installed offers opportunities for a large amount of investigations at a small cost. Because of the difference in the character and formation of the sub-soil, we believe it will be necessary to continue the study of the seepage and ground water conditions at Billings along identically the same lines as on the Experiment Station farm.

AGRONOMY DEPARTMENT.

ALFRED ATKINSON, *Agronomist.*

The report of this department as presented at this time is in a large measure a report of progress. Except for the report on variety tests no conclusive results are given. This is because of the fact that the department was established under its present management during the Spring of 1905, and the work now being carried on was begun at that time. There are therefore but two years results at hand, which do not warrant the publication of definite conclusions in most lines.

VARIETY TESTS OF CEREALS.

VARIETY TESTS OF BARLEY.

The following tables presents the average results of two years tests with twenty three varieties of barley. These are arranged in order of their yield of grain per acre.

TABLE 1.—YIELDS OF DIFFERENT VARIETIES OF BARLEY

Name of Var'ty	Nature of Head	Standard wt. per bu.	Yld of Gr. per acre		Yield of Straw per acre	Weight per Meas'd bus.	Days to Mature
			Lbs.	Bu.			
1. Guy Mayle	Hulless ..	60	4596.0	76.6	1.86	60.0	123
2. New Zeland	Two rowed ...	48	4262.4	88.8	2.27	48.5	127
3. No. 5590.....	Two rowed ...	48	4233.6	88.2	2.73	51.0	122
4. Nepbant	Hulless ..	60	3828.0	63.8	1.77	61.0	119
5. California Prolific	Two rowed ...	48	3806.4	79.3	2.18	52.2	123
6. Scotch Chevalier.	Two rowed ...	48	3691.2	76.9	1.99	50.0	123
7. Del Norte	Hulless ..	60	3516.0	58.6	1.63	60.0	121
8. Princess	Two rowed ...	48	3460.8	72.1	2.22	50.5	120
9. White Hulless ...	Hulless ..	60	3426.0	57.1	1.66	58.5	116
10. No. 7583... ..	Six Rowed	48	3345.6	69.7	1.79	45.0	121
11. Odessa	Six Rowed	48	3052.8	63.6	1.78	52.0	119
12. No. 5592	Two rowed ...	48	3000.0	62.5	1.54	53.0	119
13. Bavarian	Two rowed ...	48	2899.2	60.4	1.58	47.5	119
14. No. 5472 ..	Two rowed ...	48	2865.6	59.7	1.67	52.5	117
15. McEvans Hulless	Hulless ..	60	2754.0	45.9	1.08	58.0	117
16. Berkeley	Two rowed ...	48	2740.8	57.1	1.96	50.5	114
17. Hannchen	Two rowed ...	48	2740.8	57.1	1.95	49.5	115
18. Chevalier	Two rowed ...	48	2726.4	56.8	1.73	52.0	115
19. Kinna Kulla	Two rowed ...	48	2438.4	50.8	2.00	47.0	115
20. Black Hulless ...	Hulless ..	60	2334.0	38.9	2.17	60.5	118
21. Canadian Thorpe.	Two rowed ...	48	2323.2	48.4	1.43	52.0	116
22. Mandscheuri	Two rowed ...	48	2064.0	43.0	1.82	46.5	110
23. Minnesota 105 ...	Six Rowed	48	1512.0	31.5	1.15	49.5	119

It will be noted that the Guy Mayle, a dark kernalled hulless variety gives the largest yield. This class of barleys weigh sixty pounds to the bushel and being hulless, have no brewing value. They are used wholly for feed. The straw is usually short and has a tendency to break just below the head as soon as the crop begins to ripen.

New Zealand, the variety standing second, is a two rowed, high grade brewing barley. It has been grown at the Experiment Station for seven years and has given uniformly high yield. The berry is uniform in size and bright in color.

Some demand is being shown for a six rowed brewing barley, it being claimed that the large two rowed varieties produced under Montana's most favorable condition, do not furnish enough hull for filtering purposes. In order to meet this, several six rowed varieties are being grown. The grain is not so large but the head bears six instead of two rows of kernels, the number of grains is much greater? The tests so far have shown a yield much below the six rowed or hulless kinds. However, most of those tested so far were from imported seed, so better returns may be looked for after they are acclimated.

The following table shows the comparative returns from the different classes of barley grown.

TABLE II—YIELDS FROM DIFFERENT CLASSES OF BARLEY.

Kind of Barley	Number of Varieties	Yield of grain per acre lbs...	Yield of straw per acre. Tons	Number days to mature	Wt. per meas. bushel. Lbs.
1. Hulless	13	3408	1.69	119	59.7
2. Two Rowed	13	3168	2.00	119	50.5
3. Six Rowed	4	2496	1.64	117	48.3

From the foregoing compilation of the results of the barley variety tests; the following conclusions may be drawn:

1. The largest feed returns come from the hulless barley.
2. The two-rowed varieties give much larger yields than the six rowed varieties.
3. In the two and six-rowed varieties, large yields of grain are associated with large yields of straw.

4. An average of the varieties tested shows a yield of 1.26 pounds of straw for each pound of grain in the two rowed varieties; 1.31 pounds of straw to each pound of grain in the six rowed varieties; and one pound of straw to each pound of grain in the hulless varieties.

5. Early maturing varieties are light yielding varieties.

SPRING WHEAT VARIETY TESTS.

The following tables show the average of two years tests (1905-6) with twenty-three varieties of spring wheat. These are placed in the table in the order of their yield of grain per acre.

The Glyndon 692 gave the highest average returns. This is a good milling variety and was, with the Glyndon 650-715, originated by Minnesota Experiment Station. These have all shown themselves to be superior yielding varieties and we believe will be valuable varieties when distributed to the Montana growers.

The variety standing second is a Macaroni wheat grown from seed procured from the Ontario Experiment Station. This variety promises well as a dry land as well as an irrigated wheat.

The Red Fife wheat of Manitoba origin, which gave the lowest yield, is the Canadian Northwest No. 1. It was imported from the Manitoba Experimental Station two years ago and may give higher returns after it becomes acclimated.

TABLE III.—YIELDS OF DIFFERENT VARIETIES OF SPRING WHEAT

Name of Variety	Kind of Wheat	Yield per acre		Yield per acre straw	Nature of Head
		gr.			
		Lbs.	Bus.		
1. Glydon 692	Red, Milling	3420	57.0	2.35	d
2. Wild Goose (Canadian origin)	Macaroni	3342	55.7	3.14	rded
3. Glyndon 715	Red, Milling	3324	55.4	3.23	d
4. Monarch B.	Red, Milling	3288	54.8	2.76	d
5. Kubanka (Mont. origin)	Macaroni	3254	54.4	2.92	rded
6. Opal	Red, Milling	3228	53.8	2.46	d
7. Glyndon 650	Red, Milling	3180	53.0	3.26	d
8. Russian	Red, Milling	3180	53.0	2.98	d
9. Stanley	White, Milling	3174	52.9	2.97	d
10. Percy	Red, Milling	3102	51.7	3.17	d
11. Kubanka (Dakota origin)	Macaroni	3000	50.0	2.52	rded
12. Red Fife (Montana origin)	Red, Milling	2952	49.2	2.99	d
13. Bart Tremenia	Red, Milling	2922	48.7	2.98	rded
14. Yellow Gharooka	Macaroni	2820	47.0	2.12	rded
15. Minnesota 169	Red, Milling	2808	46.8	2.70	d
16. Wild Goose (Mont. origin)	Macaroni	2802	46.7	2.72	rded
17. Minnesota 163	Red, Milling	2772	46.2	2.46	d
18. Russian 2955	Red, Milling	2718	45.3	2.95	rded
19. Kufan 929	Red, Milling	2682	44.7	2.96	rded
20. Speltz	Feeding	2659	55.4	2.38	d
21. Pellissier	Macaroni	2622	43.7	1.89	rded
22. Emmer	Feeding	2467	51.4	2.44	rded
23. Red Fife (Mont. origin)	Red, Milling	1914	31.9	1.74	d

Comparative Returns From Different Classes of Spring Wheat.

Class of Wheat	No. of Va's. ...	Yield of grain per acre.....	Yield of Straw per acre	Days to Mature	Wt. per Meas'd bu....
Common wheat	15	2977 lbs.	2.80 tons	131	58.9 lbs.
Macaroni wheat		2975 lbs.	2.55 tons	128	60.1 lbs.
Feeding wheat	2	2563 lbs.	2.41 tons	131	47.7 lbs.

Three different classes of wheat are represented in the twenty-three varieties reported. These are, (a) the common milling class of which there are fifteen varieties; (b) the Macaroni class of which there are six varieties; and (c) the Feeding wheat of which there are two varieties. The foregoing table shows the returns from the average of the varieties in each class.

The common milling wheats include the common white and red varieties grown generally and sold for milling purposes. These may have either bearded or bald heads.

The Macaroni varieties are peculiar on account of their large and very hard grains. They obtain their name from the use to which they are put, viz., that of making macaroni products. These wheats grow very tall, are always heavily bearded, and do well on non-irrigated land. They are not in general demand as milling wheats though they make a high quality of flour, and we believe will come into use for bread making purposes. At present they are used principally for feeding to stock and for making macaroni.

In the feeding wheats are included the Emmer and Speltz. These are peculiar in that the grain remains enclosed in the hull, the head simply breaking up at the time of threshing. They furnish very good stock food and do well on non-irrigated lands. Their standard for weight per bushel is forty-eight pounds.

The comparison as brought out in the table shows an almost identical yield of grain in the common and macaroni varieties, and a much smaller yield in the feeding varieties.

The yield of straw is greatest in the common wheats and least in the feeding wheats.

The macaroni wheats mature the most quickly and give the greatest weight per bushel.

VARIETY TESTS WITH OATS.

Thirty-four varieties of oats have been grown for the past two years. The purpose in these tests is to determine the best yielding early varieties, as there is a growing demand for such on the non-irrigated farms; and to select and develop large yielding varieties.

The unusually heavy August precipitation 3.59 inches with .71 inches as the normal amount, delayed ripening the oat varieties 11 days, as compared with 1905. For this reason a detailed report of varieties is not given at this time. As in former tests, the Progress, Swedish Select and Siberian varieties are the highest yielders.

PERCENTAGE OF HULL IN OATS.

Since the hull of oats contains a high amount of crude fiber, the percentage present in any variety has an important bearing on the quality. The average percentage of hull in American and Canadian varieties of oats is nearly 30 per cent. Careful investigations as to the percentage of hull in the thirty-four varieties grown at the Montana Experiment Station during 1906, shows an average of 24.75 per cent of hull in all varieties. This is over 5 per cent below the average of the varieties generally grown and indicates a marked superiority in Montana grown oats. One variety, Salzer's Big 4 had as low as 20 per cent of hull, while the Sparrowhill, a variety introduced by the Department of Agriculture during 1905 had 29.8 per cent of hull. While this last variety shows a high percentage as compared with some others, this amount of hull is almost identical with the average varieties grown in other localities.

CORN ACCLIMATION.

During the summer of 1906 some corn improvement work was begun. The idea in this work is to develop the most superior strains of corn, so that they may be profitably grown under Montana conditions.

Corn is a very high grade finishing feed. It is high in starch and oil, the constituents which produce fat most cheaply, and if it were available for the live stock feeders the necessity of shipping stock to market before it was finished would be entirely set aside. Corn is also a large yielder giving high returns from an acre.

Again corn being an intertilled crop is valuable in the rotation. It can be cultivated easily, and thus gives opportunity to clean this field of weeds. The crop comes in for harvesting after the other grain crops have been removed, thus distributing the work of the farm over a longer period, and lessening the rush in the harvesting season.

Two methods may be adopted whereby the corn of any locality may be improved. High grade corn may be imported and by selecting only the ears which ripen best, it may be acclimated to the new locality; or by rigid selection it may be improved and brought up to a more profitable standard. During 1906 the efforts were directed chiefly along the line of acclimating a high grade corn to Montana conditions. It is the plan to include some selection work in the coming years.

The work was carried on in the Yellowstone and Bitter Root valleys, as these localities seemed to offer about the best natural corn conditions.

Seeds of the Reid's Yellow Dent, a high grade dent corn, was procured from Northern Iowa, and planted on sixteen different farms in the Yellowstone valley, and on one farm in the Bitter Root valley. As the product from all ears does not give stalks which mature their grain in the same way, the grains from each ear were planted in rows by themselves. This affords an opportunity to select from those ears which gave the most perfectly matured crops.

The corn was planted between May 12th and the 16th and some ears which showed almost perfect maturity were gathered October 10th. Later, a large percentage of the remaining ears ripened up, so that abundant seed is at hand for next years planting. From the experience of the past season we believe that this strain can be perfectly acclimated in from three to five years.

In connection with this corn work we wish to express our appreciation of the help-ful co-operation of those who so kindly furnished the ground for the growth of the corn, and gave attention to the planting, caring and harvesting. These gentlemen are: Messrs. I. D. O'Donnell, W. B. George, G. W. Conrick, William Birely, J. T. Graham, Chas. O'Donnell, S. J. Hopple, J. M. Walker, G. F. Bartlett, A. Sansome, John Summers, C. H. Perrine, Austria North, W. F. Snyder, Geo. Barling, H. P. Vermlye of Billings, and Dr. W. P. Mills of Missoula.

SOIL CULTIVATION TEST.

In areas of light precipitation and high evaporation early and continuous spring cultivation of the soil up to seeding time is recommended. This is because of its effect on conserving the moisture, warming the soil and bringing about a good seed bed condition most easily.

In order to get definite data on the above points a cultivation experiment was begun the past season. Six acres were used in the test, two acres being fall plow and the remaining four left until Spring.

In the Spring one acre of the fall plowed area was cultivated as early as the ground was sufficiently dry, and the surface kept stirred up until seeding time. Two acres of the unplowed ground were plowed as early as possible in the Spring, one acre kept cultivated, and the other left untouched. The remaining two acres were left unplowed until just before seeding time. The entire area was sown at the same time and with the same crop.

Moisture determinations were made on each plot at the time of first cultivation; just before seeding and just before irrigating. Determinations were also made as to the available nitrogen at the above mentioned times.

A careful record was kept of the amount of work put on each acre to bring it into good seed bed condition, and the yield from each acre is carefully ascertained. In this way we hope to determine the most economical way of conducting the Spring cultivation, as well as to learn something of the reasons for any difference in returns that may be noted.

EXPERIMENTS WITH ALFALFA.

Alfalfa investigations are being conducted to determine the following: The comparative yield of different varieties; comparative yield of crops grown from different amounts of seed, and the comparative returns from crops sown with and without a nurse crop.

In the variety test seed from fourteen different sources is included. Seven of these strains are of the Turkestan variety and were procured from Europe through the United States Department of Agriculture. For the remaining seven of the common variety the differences are based on the differences in climatic condition

where the seed was produced. Two are Eastern grown, two are from Northern and one is from Central Montana, and the remaining two are from the Southern states.

In the 'rate of seeding' test, plots are seeded with the following amounts, 4, 8, 12, 16, 20, 24, 28, 32 and 36 pounds per acre. Determinations as to the comparative yield and value of the hay produced are being made. After sufficient data has been accumulated, so that safe conclusions can be reached on the above, it is the plan to test the seed producing power of plots seeded at the varying rates.

In the test to determine the relative returns from seeding alfalfa with and without a nurse crop, two plots, each one acre in area, were seeded to alfalfa the same day. Immediately following, sixty pounds of seed oats were sown on one plot, and in order that the cultivation might be identical, the empty drill was run over the remaining plot. The oats were allowed to mature, which required 119 days, and harvested a yield of 83 bushels from the acre.

The plot on which alfalfa alone had grown was cut twice during the season, but no hay was taken from it. There was therefore a decided gain the first year from the plot growing the nurse crop.

During the summer of 1906 two hay crops were weighed from each acre with yields practically identical. Of course safer conclusions can be gained when two years alfalfa returns can be considered but judging from the results so far, it would seem that whatever yield is harvested from a nurse crop grown with alfalfa, is clear gain, as it seems to exert no harmful effects on the young plants.

From the nature of the test we believe that we will be warranted in giving out definite conclusions after one more years' work.

The soil on which these tests are being conducted is an average Bozeman silt loam, underlaid at a depth of four feet with an open gravelly layer. It produced clover during 1903 and 1904 and was plowed during the Fall of 1904. As early in the Spring of 1905 as the soil was dry enough to be worked without puddling, it was disked and harrowed. From this time until the seed was sown, May 6th, it was kept in a good mulch condition.

During 1905 no hay was taken from the plots. July 11th. when the alfalfa had attained an average growth of ten inches, it was cut

back with the mower. The water was immediately turned on and all plots irrigated. August 2nd, the crop was again cut back and the plots again irrigated.

During 1906 two crops of alfalfa were harvested. A third cutting was made but on account of continued wet, no accurate weights could be procured.

Detailed results from these investigations are not given at this time, as any general conclusions that might be indicated could not be accepted on the work of one year since seasons differ widely. Full returns will be published as early as sufficient data is at hand.

DAIRY DEPARTMENT.

W. J. ELLIOTT, *Dairyman*.

AGE OF CREAM AS RELATED TO QUALITY OF BUTTER

With the advent of the hand separator on the farm the creamery products, experts tell us, are gradually deprecating in quality. In other words the average butter as produced in the creamery today is not up to the standard of that some years ago, and experts are beginning to lay the blame for this upon the improper care given to the cream on the farm. When milk was delivered at the creameries every day, there was but little chance for it to become tainted with objectionable flavors. But now that the creamery patron has the hand separator there appears to be such a small amount of cream that he thinks it is not necessary to go to the creamery every day, and thus delivers the cream three times per week or perhaps only twice. It is here where the trouble comes in; cream standing about the house becomes sour or takes up taints and hence produces an inferior article of butter.

Considering these facts, it was planned to try and find what was the effect on the character of the butter when made from cream of different ages. In other words, is the practice of delivering the cream to the creamery, twice per week or three times per week, as a great many farmers desire to do, seriously detrimental to the character of the butter.

It is a well known fact that the fat of milk is not a single fat, but is rather a combination of fats, some of them hard and some of them soft; so it was our desire to find out what was the effect of keeping cream for a number of days before churning, on:

1. The churnability of the cream.
2. The character of the fat as judged by its melting point.

For this experiment four different groups of churnings were made. In group I there was cream four days old, two days old and a churning of freshly separated cream. In groups II and III and IV there was cream two days old, one day old, and freshly separated cream. To all of the samples a starter was added in sufficient quantity to produce the acidity given in the tables below. To the freshly separated cream 25 per cent of starter was added in each case. The following table gives the results:

TABLE I—Results of Churning Four Groups of Cream of Different Ages.

Group	Age of Cream.	Acidity of Cream when Churned	Temp. of Cr'm in Churn	Temp. of work room	Min. in Breaking . . .	Time to Churn	Temp. of butter Milk	Temp of wash Waters
			Dg. F	Dg F			Dg. F	Dg. F
I.	Fresh	.36 per ct.	50	68	15 min.	22 M	57	52
	1 day	.64 per ct.	50	70	17 min.	20 M	57	52
	2 day	.58 per ct.	49	68	14 min.	20 M	58	52
	4 day	.58 per ct.	50	68	16 min.	24 M	58	52
II.	Fresh	.27 per ct.	52	70	13 min.	15 M	60	58
	1 day	.20 per ct.	51 $\frac{3}{4}$	68	9 min.	11 M	60	58
	2 day	.54 per ct.	52	72	15 min.	19 M	60	58
III.	Fresh	.26 per ct.	52	69	15 min.	19 M	58	52
	1 day	.58 per ct.	48	68	15 min.	18 M	59	53
	2 day	.54 per ct.	52	71	10 min.	12 M	59	53
IV.	Fresh	.29 per ct.	49	68	18 min.	29 M	58	51
	1 day	.51 per ct.	48	70	18 min.	28 M	59	52
	2 day	.51 per ct.	48	71	16 min.	27 M	60	51

TABLE I—(Continued)

Group	Age of Cream.	Melting point of butter when Fresh	Aver. Melt. pt. for 1st 2 wks...	2nd two wks...	3rd two wks...	4th two wks...	5th two wks...	6th two wks...
		Dg. F	Dg. F	Dg. F	Dg. F	Dg. F	Dg. F	Dg. F
I.	Fresh	88	89.6	88.7	89.3	88.5		
	1 day	88	89.1	89.5	89.2	88.2		
	2 day	90.5	90.8	89.5	88.8	88.2		
	3 day	88.5	90.1	88.5	87.2	88.2		
II.	Fresh	89	92.7	89.5	89.2	89	88	79.2
	1 day	86	91.7	89.6	89	88	88.2	82.8
	2 day	88	92.8	90.2	90.5	88	89.2	86.4
III.	Fresh	95	95.2	91	89.5	89.8	89.7	82.8
	1 day	92.5	90.1	89.5	88.5	88	88	82.8
	2 day	93	91	90.3	89	88	89.2	Broke
IV.	Fresh	88.5	89.8	88.5	89	88.5		
	1 day	90	90.6	90.6	89.9	89.2		
	2 day	91	90.5	89.2	88.3	88.2		

THE CHURNABILITY OF THE CREAM.

As far as the churnability of the cream was concerned little difference was noted, as this appears to be influenced more largely by the temperature and acidity of the cream, and the temperature of the work room.

THE MELTING POINT OF THE BUTTER FAT.

In considering the melting point of the butter fat we noted a distinct difference between the old and fresh cream. We here insert a table giving an average of all of the melting points of butter made from the fresh cream, one-day old cream, two-day old cream, and the four-day old cream. The butter made from each of these churnings was kept for ten weeks and the melting point was taken three times each week during the ten weeks. The following table gives the average melting point for each two weeks of the test, beginning with the actual melting point taken the day the butter was made.

TABLE II—Average Melting Point of Butter Made From Fresh Cream, Cream One Day Old, Two Days Old And Four Days Old.

Age of C'm	Fresh	2 wks.	4 wks.	6 wks.	8 wks.	10 wks
Fresh....	90.1	91.7	89.9	89.2	88.9	88.8
1 day	89.1	90.4	89.8	89.1	88.3	88.1
2 day	90.6	91.2	89.8	89.4	88.1	89.2
4 day	88.5	90.1	88.5	87.2	88.2	88.2

As the exact point we wish to bring out in the foregoing table may be seen much more readily when this table is presented in diagram we here give the melting points of the butter made from cream of the different ages.

DISCUSSION OF RESULTS.

One of the interesting facts illustrated by this table is that for the first two weeks after churning the melting point of butter is higher than it ever is again, and that after the first two weeks the general tendency of the melting point is to become lower and lower. There is, however, a slight variation in the case of the butter from two days old, and four days old cream. At the 10th and 8th weeks respectively each of these samples makes a slight rise in melting point. The butter from two days old cream rises to within 1.4 degrees of its original melting point; while that from four days old cream rises to within .3 of a degree of its starting point. But the main tendency in every sample after the first two weeks is downward. The butter evidently becoming softer after that period as evidenced by its lower melting point. Now whether or not the character of the butter fat changes, or what are the changes that takes place, we are unable as yet to state; but this fact is demonstrated that after the first two weeks the melting point of the but-

ter fat tends to lower when kept in an average creamery refrigerator.

A deduction from the above facts would be that if we are desirous of having the butter retain its hard, firm body, we should plan to have the butter reach the consumer's table sometime before it is two week's old, if it is intended for immediate consumption.

We intend to follow out this line of work, to verify the results already obtained, and to answer three more questions, viz:

First, does the character of the butter fat change, and if so how?

Second, can the period of hard butter of high melting point be materially extended by low temperatures, and,

Third, would it be economical to do so?

REPORT OF THE DAIRY HERD.

During the year the scales and Babcock test have been used regularly to measure the producing capacity of the dairy herd. The result has been that the value of the herd as a money producer is gradually increasing.

We are particularly unfortunate in failing to get quite a number of the cows bred during the year, so that they were dry for such a length of time as to seriously affect the yearly results if their record were included. These animals have, therefore, been dropped from this year's record. Another animal which, during the year 1905, only gave a profit of \$18.25 was given another trial for 1906, when her profit was \$27.20. As this was so far below the average of the herd she was fattened and sold.

TABLE III—Giving a Record of the Herd From Dec. 1, '05 to Nov. 30, '06.

Name of Cow.	Days milked ..	Days Dry	Lbs. of Milk ..	B. F. per Cow .	Equivalent in Butter	Butter at 25c per lb.	Skim Milk at 15c per 100 ...	Total income per Cow
Buttercup	314	49	4817.9	270	315	\$ 78.75	\$ 6.72	\$ 85.47
Dell	282	83	4802.8	164.4	182	45.50	6.95	52.45
Stub	294	71	6994.9	266.5	311	77.75	10.08	87.83
Celia	237	128	5021.9	228.2	266	66.50	7.47	73.97
Blackie	334	31	6669.6	269.5	314	78.50	9.60	88.10
Bess	295	70	7392.2	322.9	377	94.25	10.62	104.87
Veda	296	69	6413.7	245.4	286	71.50	9.24	80.74
Kate	365	...	6498.8	291.1	340	85.00	9.36	94.36
Sallie	254	111	7399.3	283.6	330	82.50	10.67	93.17
Cherrie	365	...	7510.8	358.8	418	104.50	10.72	115.22
Pied	318	47	7102.9	264.8	308	77.00	10.25	87.25
May	236	129	5599.3	209.1	244	61.00	8.10	69.10
*Dame Hunter	110	129	2517.5	125.5	150	37.50	3.60	41.10
**Bessie Winns comb.	91	129	2545.3	126.1	152	38.00	3.62	41.62
Av. excepting last two. See notes.....	301	64	6581.9	273.6	319.9	79.75	9.34	89.09

*Dame Hunter was received from Dr. Mills of Missoula on August 12, '06, and had only been milked 110 days up until the close of the year (Nov. 30, '06.)

**Bessie Winn's Comb. was also received from Dr. Mills August 12th. She became fresh Aug. 31st, hence has only been milked 91 days up until the close of the year (Nov. 30, '06.)

AVERAGE OF HERD FOR TWO YEARS.

The average of the herd this year is considerably above that of last year, as seen by the following comparison:

TABLE IV—Comparison of Herd Record for 1905 and 1906.

Total income from cow	Skim milk at 15c per 100 ..	Value at 25c per lb.	Butter per cow	Butter fat per cow	Av. lbs. milk per cow	Days each cow was dry	Days each cow milked ...	
Average for 1905 ...	291.6	73.4	5992.4	249.7	291.4	72.83	8.84	81.61
Average for 1906 ..	301	64	6581.9	273.6	319.9	79.75	9.34	89.09

This is only an average herd of Montana bred cows having been purchased from the farmers of Gallatin valley, and we are endeavoring to show what can be done by a system of grading up with pure bred dairy sires, and also by using the scales and Babcock tester in weeding out the least profitable cows each year.

HAY WORTH \$16.34 PER TON AFTER PAYING ALL EXPENSES
OF FEED AND LABOR.

It cost on an average \$32.45 per cow each year to pay for her hay, grain and pasture, figuring hay at \$5.50 per ton, grain at \$1.00 per 100 lbs and \$1.00 per month for pasture. But even after charging the cows up with all she eats at fair market prices, and also deducting a fair amount for all labor connected with the business, they are still returning us, over and above all cost of labor and feed, three times market prices for the hay.

By referring to the table above it will be seen that the average income per cow is \$89.09. This amount does not include the calf nor the value of the manure. We allowed \$4.00 for the value of the calf, and \$6.00 for the value of the manure,—prices which we think all will agree are very conservative. Thus we have \$99.09 as the total average income for each cow.

Now, let us deduct from the average total income of each cow the average value of grain fed, which is \$11.29 (at \$1.00 per 100 lbs.) and the pasture at \$1.00 per month, together with three cents per pound for manufacturing the butter, (the average price charged at the creameries) and also a total of \$20.00 for looking after each cow during the year. Putting this in tabulated form we have the following:

Total average income per cow.....	\$99.09
Average cost of grain fed each cow.....	\$11.29
Average cost of pasture per cow (5 months).....	5.00
Cost of manufacturing butter at 3c per lb.....	9.57
Cost of labor for each cow.....	20.00
<hr/>	
Total.....	\$45.86
<hr/>	
Balance in favor of cow....	\$53.23

Now, this amount represents the value of hay fed during the winter.

The cows were fed in the barn for seven months, and consumed on an average per animal 925 lbs of hay per month, making a total of 6475 lbs., or practically three and one-fourth tons for each cow. Thus, three and one-fourth tons of hay fed to the cow brought in

Cherrie, Best cow in the Montana Experiment Station herd for the year 1906.

Milk produced	7510.8 lbs.	Value of butter at 25c per lb.....	\$104.50
Average test	4.6 %	Value of skim milk at 15c, per 100	
Butter fat produced..	358.8 lbs.	pounds	10.72
Estimated butter	418.0 lbs.	Total income from cow.....	115.22

Bess, Second cow in the Montana Experiment Station herd for the year 1906.			
Milk produced	7392.2 lbs.	Value of butter at 25c per lb.....	\$ 94.25
Butter fat produced..	322.9 lbs.	Value of skim milk at 15c, per 100	
Average test	4.3 %	pounds	10.62
Estimated butter	377.0 lbs.	Total income for 1906....	\$104.87

Sallie, Third cow in the Montana Experiment Station herd for the year 1906.

Milk produced	7399.3 lbs.	Value of butter at 25c per lb.....	\$ 82.30
Average test	3.8 %	Value of skim milk at 13c, per 100	
Butter fat produced..	283.6 lbs.	pounds	10.57
Estimated butter	330.0 lbs.	Total income for 1906.....	93.17

a net return of \$53.23, or \$16.34 per ton. This, after allowing a fair market value for all grain fed (\$1.00 per 100 lbs.), and \$1.00 per month for pasture, as well as charging her with three cents per pound for manufacturing the butter, and besides charging her with \$20.00 for the trouble of milking and feeding her.

Now, let us sum up to see what we have received from the dairy cow. She has paid us:

- (1) \$20.00 for milking and feeding her.
- (2) \$16.34 per ton for all hay consumed.
- (3) \$ 1.00 per hundred for all grain eaten.
- (4) \$ 1.00 per month for pasture.
- (5) And over and above all this she pay 3c. per lb. for the trouble of converting her product into butter.

Besides all the above this system permits us the privilege of marketing all our farm products right at home.

MARKETING BUTTER VS. HAY.

There is also the difference in favor of delivering the cream or butter at the market or creamery, as compared with the marketing of scores of tons of hay. In our particular case we would have had to draw 170 tons of hay to market at \$5.50 per ton, to receive the same amount of money as we received from delivering one and seven-tenths tons of butter. But what about the effect on the land. Investigations show that for every ton of clover hay removed from the farm, there is removed \$2.40 in ash elements, which are not returned. Now, in selling 170 tons of hay off the farm, we remove \$408.00 in ash elements, while in selling one and seven-tenths tons of butter, we do not remove \$1.00 worth of value from the fertility of the soil, because the elements that go to make up butter are those that are obtained from the air by the plants.

DAIRYING PAYS.

It was our intention three years ago to prove by actual demonstration that a herd of ordinary Montana cows could be made to pay. And as a result of carefully weeding out the unprofitable animals and giving due care to the handling and breeding of the herd, we have this year obtained \$16.34 per ton for hay by feeding it to dairy cows. We hope to greatly increase this amount after

we start to use full blood dairy sires in the further grading up of the herd.

RETURNS FROM AN ACRE OF PASTURE

Another line of work taken up by the Dairy Department, in co-operation with the Director, was a study of the returns from a permanent pasture. Only a short summary of this work will be given here as the results complete will come out in bulletin form a little later.

During the summer, from June 1st to October 13th, thirty head of cows (22 milking and 8 dry), and six head of yearlings, were pastured on 30 acres. This pasture grew so abundantly that the 30 head could not keep pace with the clover, and one end of the field, consisting of a fraction over nine acres, was fenced off to cut for hay. From this nine acre piece twelve tons of hay were cut. The irrigation water was then turned in on the hay stubble, and in ten days it was opened again for pasture. During this time (June 1st to October 13th), 48,783 lbs. of milk were produced on the 30 acres from which 2,440 lbs. of butter were made. This butter sold at 27c. per lb., realizing \$658.80. To this add twelve tons of hay at \$5.50 per ton, or \$66.00. The total weight of the animals when turned in on the pasture on June 1st was 38,409 pounds. On October 13th their weight was 41,126 pounds, thus we had a gain in weight for the herd of 2,717 pounds, at 3c. per lb., making an additional gain of \$81.50.

To this add 46,300 pounds of skim milk at 15c. per 100 pounds, and from the 30 acres we have:

Value of butter produced.....	\$658.80
Skim milk at 15c per 100 lbs.....	69.51
Hay cut.....	66.00
Gain in weight of herd.....	81.50

Total from 30 acres\$875.81 or \$29.20 per acre.

COMMENTS ON THE RETURNS FROM THE DAIRY HERD.

We would not have it understood that this is a high class dairy herd, for it is only an ordinary herd of Montana bred cows, purchased from the farmers of the Gallatin Valley. The object was to

show what could be done with the ordinary herds of Montana cows under average conditions when handled in an intelligent manner.

We believe that the returns could be greatly increased with a higher grade herd and by careful selection and handling, see what improvement can be made with each succeeding year. This is also what we would advise the average farmer to do. Do not put a large amount of money into a highly bred herd before you have the facilities for caring for them and understand how to handle them. Start with the best cows you have, weeding out as soon as possible the poor producers. Get the best sire you can procure and grade up the herd, watching and studying carefully as you gradually improve the herd with the better blood. Then by the time you have worked up to almost high grades you will fully understand how to handle them and can safely buy the best animals you can get.

During the time the farmer is grading up his herd, and before he has come to the place where he is practically or entirely dealing with the best specimens of the dairy breeds, he is yet in a profitable business because no more profitable way can be found of disposing of the hay grown on the farm than by selling it to good dairy cows.

CAUSES OF VARIATION IN TEST OF CREAM.

A second line of work taken up by the Dairy department was to try and answer by actual test a question that has been coming to us frequently from the new creameries. The question is: "With the same separator and with the same herd, what causes the percentage of butter fat in the cream to vary from day to day?"

DIFFERENT TEMPERATURES.

We first tried different temperatures of milk. All milk for this experiment was run through the same separator, running by power, so that the speed was constant. We separated milk at 60 degrees F., 65 degrees F., 75 degrees F., 85 degrees F., 95 degrees F., and 105 degrees F., and the average of six different tests gave us the following:

Temp. of milk separated....	60F.	65F.	75F.	85F.	95F.	105F.
Average per cent fat.....	20.6	21.8	25.	27.5	26.5	29.7
Capacity of sep. in lbs....	599lb.	638lb.	647lb.	656lb.	661lb.	676lb.

It is evident from this table that the 'percentage of butter fat in cream depends very materially on how long the milk is allowed to cool after it is drawn from the cow and before it is separated, or in other words, depends upon the temperature of the milk. The temperature of the milk at the time of separation also plays a very important part in the capacity of the separator, as will be seen by referring to the above table.

VARIATIONS IN SPEED OF SEPARATOR.

The second test was to find what was the influence of a variation in speed of separator on the percentage of butter fat in the cream and, incidentally, on the capacity and efficiency of the separator. The results were as follows:

Turns of separator handle per minute....	50	52	57	58
Average per cent butter fat in cream.....	32.5	34	32.5	36.5
Average capacity of separator.....	501	506	495	495
Average per cent fat in skim milk.....	.7	.7	.06	.03

This table tells us that a variation in the turns of the separator handle per minute, or the speed of the separator bowl, will cause a difference in the percentage of fat in the cream. Incidentally it will also be seen that the capacity of the separator varies with the speed, and the efficiency of the separator is also very materially influenced.

FULL AND PARTIAL CAPACITY.

A third experiment along this same line was in the running of the separator at full capacity and half capacity. The results were as follows:

Per cent. of fat obtained, full capacity, with milk at 80F....	25%
Per cent. of fat obtained, partial capacity, with milk at 80F..	34%
Per cent of fat obtained, full capacity, with milk at 90F....	23.5%
Per cent. of fat obtained, partial capacity, with milk at 90F..	31%

In this test the running of the separator at only partial capacity produced a very much richer cream.

RICH AND POOR MILK.

The next test made was with rich and poor milk. The results were as follows:

Per cent fat in milk.....	4.5	3.6
Average butter fat in cream.....	34.5	24.

Here again a difference of a trifle less than 1% butter fat in milk causes a difference of over 10% in the butter fat in the cream.

AMOUNT OF WATER USED IN FLUSHING THE SEPARATOR.

Continuing the same line of tests, different amount of water were used to flush out the bowl after separating:

Per cent. butter fat in cream when 1 qt. water was used....34.5

Per cent butter fat in cream when 3 qts. water was used..31.7

We believe that the above is one of the most fertile causes of variation in the test of cream, for, as a rule, the farmer pays no particular attention to the exact amount of water used to flush out the separator.

IRREGULAR SPEED OF SEPARATOR.

Two tests were conducted with reference to irregular speed of the separator. In this test the speed of the separator was increased and slackened irregularly during the separating process, as might be unconsciously done by one who did not particularly watch the speed of the separator. In one test we secured 34% fat in the cream, and in the other 29.5% fat.

DIFFERENT ACIDITY.

In separating milk of different acidity we found no difference, securing the same percentage of fat in each case. However, the difference in acidity was only slight. Had there been a greater difference we probably would have secured cream of a different per cent. fat in each case, as the tendency of ripe milk is to clog up the separator, producing a heavier and heavier cream until such time as the separator will clog up entirely.

SUMMARY.

To sum up the experiment, then, we have the following factors which produce cream of a varying percentage of butter fat:

1. Varying temperature of milk separated.
2. High or low speed of separator crank, or speed of separator bowl.
3. Varying rate of inflow of milk.
4. Milk of varying butter fat content.
5. Amount of skim milk or water used to flush the bowl.
6. The acidity of the milk separated.
7. Irregular speed of separator.

It is thus evident that even with the same separator and the same cows the percentage of fat in the cream may vary slightly or may vary considerably from day to day.

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION.
F. B. LINFIELD, Director.

FOURTEENTH ANNUAL REP

FOR THE
FISCAL YEAR ENDING JUNE 30,
1907

BOZEMAN, MONTANA
FEBRUARY, 1908

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BOZEMAN, MONTANA.

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R. A. COOLEY, B. Sc., *Entomologist*
R. W. FISHER, B. S. *Horticulturist*.
E. TAPPAN TANNATT, B. S., *Rural Engineer*
W. J. ELLIOTT, B. S. A., *Dairyman*
ALFRED ATKINSON, B. S. A., *Agronomist*
ROBERT W. CLARK, B. Agr., *Animal Industry*.
EDMUND BURKE, B. S., *Meteorologist and Assistant Chemist*
DEANE B. SWINGLE, M. S., *Assistant Botanist*.
J. B. NELSON, *Sup't. Dry Farm Work*.
H. O. BUCKMAN, B. S., *Assistant Agronomist*.
R. D. KNEALE, B. S., *Assistant Engineer*.

Post Office, Express and Freight Station, Bozeman.

All communications to the Experiment Station should be addressed to

THE MONTANA EXPERIMENT STATION,

Bozeman, Montana

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

. **LETTER OF TRANSMITTAL**

Bozeman, Montana, .

To His Excellency, Joseph K. Toole,

Governor of Montana

Dear Sir,—In accordance with the Congressional Act of March 2, 1887, and March 16, 1906, I have the honor to transmit to you the thirteenth annual report of the Montana Board of Forestry. The financial statement is for the year ending November 30, 1907. The results of investigations of the several departments are also included for the end of the State year, November 30, 1907.

Very Respectfully,

F. B. L.

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REPORT OF TREASURE

The Experiment Station of the Agricultural Co
Montana in account with the United S
1906-1907.

Ha

Dr.

To receipts from the Treasurer of the United
States as per appropriations for fiscal
year ended June 30, 1907, under acts of
Congress approved Mar. 2, 1887 (Hatch
Fund), and March 16, 1906, (Adams
Fund. \$15

Cr.

By Salaries \$ 9
Labor 1
Publications 1
Postage and stationery
Freight and express.....
Heat, light, water, and power
Chemical supplies..
Seeds, plants and sundry supplies.....
Fertilizers
Feeding stuffs
Library...
Tools, Impliments, and machinery
Furniture and fixtures
Scientific apparatus
Live stock
Traveling expenses
Contingent expenses
Buildings and land
Balance

Total \$15

We, the undersigned, duly appointed Aud
ation, do hereby certify that we have examine
counts of the Experiment Station of the Agricu

State of Montana, for the fiscal year ended June 30, 1907; that we have found the same well kept and classified as above; that the receipts for the year from the Treasurer of the United States are shown to have been \$15,000.00 under the Act of Congress of March 2, 1887, and \$7,000.00 under the act of Congress of March 16, 1906, and the corresponding disbursements \$15,000.00 and \$6,99.95; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving balances of \$no and \$.05.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts, respectively.

Signed,

E. B. LAMME }

Auditors

JOHN M. ROBINSON }

Attest:

GEO. COX, Custodian.

SUPPLIMENTARY STATEMENT

EXPERIMENT STATION MISCELLANEOUS FUND

Dr.	State	Individ- uals	Farm Pro- ducts	Total
To receipts from other sources than the United States for the year ended June 30, 1906	\$9790.00	\$2401.82	\$5982.68	\$18174.64
Cr.				
By Salaries	\$	\$	\$1000.00	\$ 1000.00
Labor	3498.70	1505.51	1797.67	6801.88
Publications	119.28			119.28
Postage and stationery	96.56			96.56
Freight and express	245.06	38.25		283.31
Heat, Light, water & power.....	675.61			675.61
Chemical supplies				
Seeds, plants & sundry supplies..	497.91	54.90	637.96	1190.71
Fertilizers				
Feeding stuffs	234.48		253.75	488.23
Library	5.00			5.00
Tools, impliments and machinery.	1762.92	184.95		1947.87
Furniture and fixtures	152.85			152.85
Scientific apparatus	214.47	135.18		349.65
Live stock	643.00		1390.50	2033.50
Traveling expenses	873.69	477.08	441.48	1792.25
Contingent expenses	219.21	5.95		225.16
Buildings and land	551.40		461.32	1012.72
Balance				

REPORT OF THE DIRECTOR

INTRODUCTION.

During the past year substantial progress was made in all departments of the Experiment Station work. At the beginning of the year a man was placed in charge of the Animal Industry work, giving his whole time to this department, so that now all divisions of our technical agricultural work are on a strong basis and prepared to push their work.

The state legislature contributed generously towards our needs last winter, increasing our maintenance fund from \$5,000.00 to \$7,500.00 per year, and the dry land fund from \$1,000.00 to \$3,000.00 per year.

Two sub-stations also were established; one a dry farm station and the other an horticultural sub-station and \$1,000 per year for each was appropriated; but to start and equip these stations properly will cost much more than the sums given.

The agricultural building, for which an appropriation of \$80,000.00 was given by the legislature, will also improve the facilities of the agricultural departments of the Station. But little use can be made of this building before the close of next year's work.

Another very beneficial move for which we have to thank the Executive Board, was the securing, with the approval of the State Board of Education, of an option on the 160 acres of land adjoining the Station farm to the south. This land, which is all under the ditch, doubles our farm land and makes it possible for us to grow all our own feed, and thus cure it in the best possible way for our feeding experiments.

While our funds have increased and additional help has been provided, yet the demands for help and the needs of the work has increased even more rapidly, so that we are at all times unable to take hold of many of the problems pressing upon us. We are, however, endeavoring to make a selection of the problems that we hope will be of the greatest permanent good to the state, and doing our best to solve and extend our knowledge about them. What

the lines of work are I will endeavor to present later in this report.

Three years ago we took up the study of dry farm problems in several parts of the state. The demand for definite information on this subject during the past years, both from the older settlers, and especially from the newer settlers of the state, has shown conclusively that we took up this work none too soon. The general agitation over the country on dry farming during the past few years, together with a new trans-continental railway crossing the state, has brought thousands of people to Montana, many of whom are spreading out over the dry bench lands. These people are meeting with a type of agriculture in which the emphasis has to be put on moisture and water supply for the soil, rather than upon fertility which is the prominent feature in the east.

There is need for the continuation for several years of investigations as to the best practices in dry farming, and it would also be desirable if funds could be found to operate several demonstration farms which should be run to show how to handle the dry farm so as to get profitable results. These farms should be for instruction, not for experiment.

There is also a demand and a necessity for demonstration or instruction farms in connection with the irrigation projects of the United States Reclamation Service. A large number of people are coming from the east and settling on these lands and they know but little about how to lay out and irrigate their farms, and the results are going to be very discouraging unless some instruction can be given them in the field. It would be a good investment for the state and also for the counties, to appropriate funds for this purpose for two or three years, as such a policy would hasten the settlement of these tracts and help the people to realize larger returns and both of these points would increase the revenue of the county or state by much more than the amount that this instruction would cost.

These demonstration farms should not be operated for experiment purposes to work out new agricultural facts, but should apply known principles to practical agricultural work on the farm. These farms should not be, nor be called experiment farms, but demonstration farms.

IMPROVEMENTS

During the year a horse barn 40 by 85 feet was constructed. This is a frame building, two stories with a gambrel roof. On the first floor are fourteen single stalls and three large box stalls. One end of the barn, 18x40 feet, is used for carriages. The passages are floored with cement, and the stalls with plank laid on cement grouting. On the second story is ample storage for hay, bedding and grain. The cost of this building completed was about \$6,000.00.

The old horse barn was divided into two parts, the logs removed and the roof and frame moved west of the Poultry yards, and they have made two very good bull sheds. Suitable yards were also built for the bulls, these being made very strong and substantial. The cost of these improvements was about \$1,000.00.

The securing of the extra 160 acres of land made it necessary to purchase additional farm machinery, and an extra team of horses. The cost of these additions was about \$1,000.00. As the nucleus of a beef herd of grade cattle, fifteen high grade Shorthorn and Hereford heifers were purchased during the fall, and these will be used to raise steers for our feeding experiments. They cost about \$300.00 for the lot.

These improvements amounting to a total of \$2,300.00, were paid for from the income of the farm.

SUB-STATIONS

The dry farm sub-stations started in co-operation with the Northern Pacific and Great Northern railways were continued last year. The railways contributed \$3,000.00 and \$2,000.00 respectively to this work besides giving free transportation to the men looking after the work and for the seeds and implements used. The work has been carried on in the same places as last year, viz.: north of Glendive, near Forsyth, in the Lake Basin north of Billings, and on the Fort Ellis Military Reservation near Bozeman. In the northern part of the state, work was continued north of Harlem and near Shelby and another station was started near Great Falls. All these are temporary sub-stations to work out some special problems. To this work the state gave \$3000.00 for the year.

Last year a new departure was made by the legislature in establishing two permanent substations, one of these for dry farm ex-

periments in Fergus County and the other for horticultural experiments in the Bitter Root valley. One thousand dollars per year was appropriated for each station, but it was also provided that the people of the district were to furnish the land necessary free of cost to the state.

It is, of course, very evident that to thoroughly equip and start a large series of experiments, the funds appropriated for these sub-stations is wholly inadequate. For the Fergus county sub-station Mr. H. H. Hobson of Lewistown guaranteed \$2500.00 for the equipment of the station. The Experiment Station and the state are under many obligations to Mr. Hobson for his generosity in this matter as without his help, the co-operation with the U. S. Department of Agriculture could not have been secured and we could not have properly started the work at this station. This, however, will not provide all that is needed, and at least \$2500.00 additional must be raised. The funds provided by the state will pay for scarcely more than the labor to be done and gives nothing for superintendence, farm machinery, buildings, etc.

The Bureau of Plant Industry of the U. S. Department of Agriculture has agreed to co-operate with us at this station to the extent of paying a superintendent, but this will increase the labor to quite an extent, and it also made necessary the investment of larger amounts in the buildings and equipment.

For the horticultural sub-station, as the land was quite a small area, viz.: 15 acres, and the work of starting was largely delayed until the second year, and as much less details have to be attended to at the start, it will be possible to organize this work on the funds appropriated.

While it has been more by good luck than good planning, yet if we are to have permanent sub-stations I believe no better points could have been selected. The station in Fergus county, located in the center of the Judith Basin, represents quite close to average dry farm conditions for the state and is also close to the geographical center of the state. The results of dry farm tests here would represent close to the average that would be obtained over the state.

There was also real need for an horticultural sub-station, as the central station at Bozeman did not represent what could be done at the more favorable fruit areas of the state.

At this point, however, I would like to urge that no more per-

manent sub-stations be established for the present. To equip such stations properly calls for large expense, and if the work is carried on, on a basis that will insure reliable and valuable results, the cost of maintenance is also going to be large. The almost universal experience has been that with a multiplicity of stations so much funds is tied up in the plant and is needed for its maintenance, that but little is left over for doing the real experimental work. Without exception best results have been obtained when the funds are concentrated into as few stations as it is possible to do the work required. The above does not apply to temporary sub-stations where the investment in the plant is small and work along a narrow line is carried on for a few years to study local problems and conditions.

These temporary sub-stations frequently partake more of the nature of demonstration farms where the results of the central station may be brought close home to the farmers of the locality. Such farms are educational rather than experimental in their character and logically belong to the extension department of the college work rather than to the experiment station department.

CO-OPERATIVE EXPERIMENTS.

The work of the station has been extended and helped very materially during the past year due to co-operation with the railways of the state and with the U. S. Department of Agriculture. Both the Northern Pacific and the Great Northern railways continued their help towards the dry farm experiments, contributing between them over \$5,000.00 beside free transportation for men and material used in the work.

Co-operative work has also been undertaken with the Bureau of Plant Industry in three directions: first, on methods of cropping and cultivation on dry land; second, on testing of varieties of grains and seeds on dry land; and third, on testing and the improvement of sugar beets on dry land. This co-operative work it will be noticed is almost wholly in the Agronomy department and for tests in dry farming, and has thus very materially helped our work in this direction.

ANNUAL REPORT

NEEDS OF THE STATION

The last state legislature made generous provision and improved quarters for the work of the Experiment Station as well as for the agricultural work of the college. The appropriation for the new agricultural building, for live stock and farm implements, has been and will be a very great help. Through the action of a clerk in the Senate, however, \$7,000.00 given for the building and repairs, was lost from the bill. We planned to use the money to improve our quarters for sheep and steer feeding. The sum may be replaced by the next legislature.

Additional shed room for the farm implements and stock and bulls is also needed, in addition to more yoke and fenced. Some additions should also be made to the building to give larger and better space for the incubators and for the storage of feed and supplies.

With the agricultural development of the state there is an increase in the demands upon the Experiment Station, and there is a constant need for gradually increasing appropriation from the state for the maintenance of this work.

STATION STAFF.

The only important change in the station staff for the year was in the chemical department. The chemist, Prof. J. H. Nutt, resigned on August 31, 1907, to take up work in the Department of Agriculture, at Washington, D. C., and Mr. J. H. Burke, assistant chemist, was placed in charge of the chemical laboratory, giving his full time to this work.

Mr. Frank Ham who was also assistant chemist, continues to do extension work and will give his whole time to the college.

In the engineering department, Mr. A. P. Anderson is assistant and Mr. R. D. Kneal of the Purdue University has taken his place.

Mr. H. O. Buckman of the Iowa State College was appointed assistant agronomist and will give all his time to the station.

AGRICULTURAL EXTENSION WORK

The demands for information on agricultural topics in all parts of the state is growing rapidly and the weight

in connection with these demands falls upon the members of the Experiment Station staff. This is no less true of the Farmer's Institute, work, which is organized under a separate board, than of other phases of Institute work.

We are, I believe, approaching a time when this work could with advantage be organized under a separate department.

THE FARMER'S INSTITUTES

Very substantial increases were made by the legislature for the Farmers' Institutes, the appropriation being increased from \$4,000.00 to \$7,500.00 per year. This made possible the engaging of a superintendent to relieve the Director of very much of the detail of this work. Prof. F. S. Cooley of the Massachusetts Agricultural College, was engaged and started to work on September 1, 1907. This arrangement will also relieve, to a considerable extent, other members of the station staff, so that I believe it will be possible to reduce the time demanded of any member to not more than two weeks for the year. This, of course, does not include special meetings which the station men are called to attend for a day or two at a time.

With a man giving his full time to the institute work we hope to see it expand and broaden on a truly agricultural extension basis and thus be as useful as possible to all the farming population of the state.

TESTS AND DEMONSTRATIONS

By reason of our work and equipment, a large amount of work comes to the various departments which has no relation to any problem under investigation. The work called for has generally an economic or other value to the individual, the company, or the community sending the request. It is essentially the getting of information of value to the inquirer and has generally no value in extending our fundamental knowledge of agricultural problems. It is thus extension, not experimental work. In addition to the kinds of work listed under this head last year, we had this year a large number of tests, to determine, suspected cases of human diseases and some of diseases of domestic animals.

CORRESPONDENCE

The correspondence of the various departments continues to increase year by year. For the past year 6,554 letters were answered. The great amount of this correspondence is in answer to inquiries for information on a multitude of agricultural topics. Most of these letters are in no way along any lines of work we are doing, but the inquiries are for information in the general agricultural field.

While most of the letters may be readily answered, others require considerable research in the library. From one-half month to nearly two months' time during the year is given to this correspondence by the various departments.

The letters sent out by each department are as follows: Chemical department 546, Biology department 750, Agronomy department 1,186, Dairy Department 1,320, Horticultural department 725, Animal Industry department 400, Engineering department 454, Director office, 1,151.

WORK OF THE DEPARTMENTS.

There has been no break in the work outlined by the various departments during the previous year. The few changes in the staff have in no wise affected the continuation of the work on hand, but the various projects are moving on towards completion. With the agricultural development of the state there is an ever increasing pressure to take up new problems and it is not at all times an easy matter to decide what shall be done and what left undone. There is, too, the constant danger of attempting to do too many things with the resulting evils.

The Biological department has kept its lines of work well in hand during the year. The weight of the energy of the department has been devoted to the two Adams problems and very satisfactory progress has been made.

Under the Hatch fund studies have been completed with the red fir cone moth, and the results have been published in Bulletin No. 70. During the year the assistant botanist has made an extensive canvas of the state for plant diseases. Apple scab has been found in two places and is quite plentiful around the northern half of Flathead Lake.

The black spot canker of apple has been found in the Bitter Root and Yellowstone valleys.

Pear blight has been located in Ravalli and Missoula counties and also in Sanders county.

These diseases have been reported to the State Board of Horticulture and measures recommended for their eradication or control.

In addition to the above the department has spent considerable time in work of a general inspection or educational character, assisting and advising with the State Board of Horticulture, identifying plants and seeds, diseases of plants and insects, and also a large number of bacteriological diagnoses for human and domestic animal diseases.

The department of Agronomy has been working along lines similar to those of the year before, though intensifying this work in some directions. Variety tests have been continued with wheat, oats, barley, peas, alfalfa, clover and potatoes. Another season will practically close the tests with most of the cereals, when work will be taken up to improve the best of the varieties. Interesting results have been also obtained in relation to the time and amount of seeding and after another year's test reports will be made on this work.

The dry farm investigations have progressed far enough to remove all doubt as to the successful and profitable cropping of the level non-irrigated lands of several sections of the state. Substantial progress has also been made in determining what methods should be followed to get these results. There are many questions yet to be worked out along this line looking towards more economic results and the greatest possible permanency in this method of agriculture.

The problems under the Adams funds have been substantially advanced during the year, and the results so far obtained promise very valuable additions to our knowledge and control over the moisture and the nitrates of the soil.

The head of the Dairy department devotes considerable of his time to agricultural extension work, in Farmers' Institutes, and to instruction to creameries and its patrons and to the study of dairy herds of the state. A study of the milking machine was started and continued during the year and some initial tests made on the melting point of butter

The principal work of the Horticultural department has been in the study of cultural methods and variety tests of vegetables, fruits and ornamental trees and shrubs. Some results, especially

with tomatoes, promise much for success with this crop in our higher valleys. A beginning has been made in the study of native fruits and ornamental shrubs. It is hoped by selection and crossing to find some varieties that will be valuable additions to those already grown in the state.

The fruit survey of the state was continued in the Flathead and Clark's Fork valleys.

Interesting and valuable results were obtained in thinning fruit in orchards in the Bitter Root valley.

The larger proportion of the work of the department of Rural Engineering for the year was done in various parts of the state and not at the Station. The most of this work was carried on under Adams funds. The first stage in the series of drainage investigations that have been carried on have been practically concluded and the results are now being prepared for publication. There are yet a few phases of this subject to be studied but these will be reported on later.

In following up the studies on the control of seepage, attention was called to the disintegration of cement in alkali soils. A bulletin, Number 69, has been published, giving the preliminary studies on this problem.

The head of the chemical department resigned on August 31, 1907, but the work was continued under the direction of Mr. Burke the assistant who has been connected with the department for several years. The department has gotten through a larger amount of work than for several years passed. In the special work of the department 384 samples were analyzed, calling for 1180 determinations, besides 273 determinations in the egg hatching experiment. For the Rural Engineering department 123 samples were analyzed, requiring 405 determinations, and for other departments 8 samples with 20 determinations.

Investigations carried on during the year in the study of vinegars and canned meats have been completed and the material is being prepared for publication.

Considerable of the time of the department was given to co-operative work with other departments. With the U. S. Bureau of Plant Industry, and the Agronomy department of the station, work was carried on with sugar beet improvement. Co-operative

work was also undertaken with Adams problems initiated by the engineering and agronomy departments.

Prof. R. W. Clark took hold of the Animal Industry department at the beginning of the year and has been gradually getting the work well in hand. Feeding experiments with a car load of steers has been continued and some results are ready for publication. An extensive series of experiments with hogs have been carried on during the year.

With the college and dairy herd a complete feeding record is being kept and from this the cost of production with the growing animal and of its milk is being determined.

The Poultry department is supported wholly by state and income funds. The endeavor has been to build up an economic flock. Trap nests have been used and records made of the number of eggs laid. All the feed given to the various pens has also been weighed. By studying the cost of feeding and the egg record of each fowl, we expect by raising our stock from the best layers to build up laying strains of the various breeds.

MAILING LIST.

The bulletin mailing list of the Station continues to grow and now numbers 6,200 names. About 3,288 copies of the bulletins are distributed in the state, about 800 are sent to other states, 85 to foreign countries and about 2,000 are sent to officers in other experiment stations of the country and to the United States Department of Agriculture.

PUBLICATIONS OF THE YEAR.

Five bulletins and the Fourteenth Annual Report were published the past year. These contain 186 pages of printed matter and 21 full page plates.

Bulletin No. 67:—Practical Beekeeping by Ralph Benton under the direction of R. A. Cooley, Entomologist. This, as its name indicates, is a practical manual on beekeeping, adapted to Montana conditions. Woven into the text of this bulletin is the results of several years observations and tests at the Montana Station. This Bulletin, therefore, presents valuable information for the beginner in beekeeping in Montana. Seventy-six pages and 8 plates.

ANNUAL REPORT

Bulletin No. 68.—Canadian Field Peas by A. Atkinson. This is a popular writeup of the Canadian field peas introduced to the Montana irrigated farm. Ten pages and three plates.

Bulletin No. 69.—The Effect of Alkali on Portland Cement by E. Tappan Tannatt, Rural Engineer, and Edmund Atkinson. This bulletin presents the results of observations on the disintegration of Portland cement, and the results of chemical studies that indicate that alkali is the cause of the trouble. 10 pages and 9 plates.

Bulletin No. 70.—The Douglas Fir Cone Moth, by E. Atkinson, Entomologist. This is a record of observations and experiments on a moth which feeds on the cones and seeds of the Douglas fir, and is destroying 95 per cent of the seeds of this tree in the neighborhood of the Gallatin valley. 8 pages and one plate.

Bulletin No. 71.—The Fifth Annual Report of the Montana Entomologist. This is a brief report on the work of the entomologist, with notes on the insects troublesome, particularly on the spruce budworm, and on an army cut worm in the Gallatin valley, and miscellaneous notes on the same species in other parts of the state for the year 1907. 24 pages.

The Fourteenth Annual Report.—This is the report of the director on the work and progress of the year, with a few pages on the work of the departments. The Meteorological report is given as an appendix to this report. 32 pages.

LIST OF STATION PUBLICATIONS.

1. Organization—Announcements.
2. Smuts of Wheat, Oats and Barley.
- * 3. Pig Feeding.
- * 4. Glanders.
- * 5. First Annual Report, Crop Statistics of Gallatin County.
- * 6. Measurement of Water.
- * 7. Small Grains and Potatoes.
- * 8. Second Annual Report—Crop Statistics of Gallatin County—Parasitic Ictero—Hermaturia of Sheep.
- * 9. Potatoes.
- * 10. Small Grains, Wheat, Oats, Barley.
- * 11. Devices for Obtaining a Constant Flow in Laterals with Variable Heads in the Main Canals or Reservoirs.
12. Third Annual Report, Spaying of Mares.
13. Drinking Water.
14. Montana Swine Feeding.
15. Larkspur Poisoning of Sheep.
16. Fourth Annual Report.
17. An Army Cut Worm—The Grain Aphis.
- * 18. The Alkali Soils of Montana.
- * 19. The Sugar Beet in Montana.
- * 20. Fifth Annual Report.
- * 21. Sheep Feeding.
- * 22. Thirteen Botanical Subjects.
- * 23. Injurious Fruit Insects; Insecticides; Insecticide Apparatus.
- * 24. Sixth Annual Report.
- * 25. Paris Green, and London Purple.
- * 26. Poultry Raising.
- * 27. Live Stock Feeding Tests, Beef Cattle, Lambs and Swine.
- * 28. Seventh Annual Report.
- * 29. Quantity of Water Used in Irrigation.
- * 30. Weeds of Montana.
- * 31. Report of Grazing and Feeding Tests, Beef Cattle and Lambs.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
- * 34. Farmers' Weirs.

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35. Report of Feeding Tests.
36. Forage Conditions in Montana.
37. Pork Production in Montana.
38. Food Adulterations.
- *39. Sheep Feeding in Montana.
40. Root Crops in Montana.
41. Sugar Beets, (1902).
42. The Codling Moth.
Ninth Annual Report.
43. Duty of Water.
44. Apple Growing in Montana.
45. The Loco, and Some Other Poisonous Plants in
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
49. Contagious Abortion in Montana.
- *50. Poultry Management and Poultry Diseases.
51. First Annual Report of the State Entomologist.
Tenth Annual Report.
52. Sugar Beets.
53. Creameries and Cheese Factories.
54. The Alkali Soils of Montana.
55. Second Annual Report of the State Entomologis
* Eleventh Annual Report.
56. Native Economic Plants of Montana.
- *57. Feeding Pigs.
- *58. Fattening Cattle.
- *59. Sheep Feeding.
- *60. Onion Culture.
- *61. Food Adulterations.
62. Third Annual Report of the State Entomologist.
* Twelfth Annual Report.
63. Dry Farming in Montana.
- *64. Fourth Annual Report of the State Entomologis
- *65. Seepage and Drainage.
- *66. Orchard Survey in the Bitter Root Valley.
* Thirteenth Annual Report.
67. Practical Beekeeping.

68. Canadian Field Peas.
69. The Effect of Alkali on Portland Cement.
70. The Douglas Fir Cone Moth.
71. The Fifth Annual Report of the State Entomologist.
The Fourteenth Annual Report.

* Out of Print.

ANNUAL REPORT

EXCHANGE LIST.

Agricultural Eptiomist, Spencer, Indiana.
American Fancier, New York, N. Y.
American Farm World, Chicago, Ill.
American Fertilizer, Philadelphia, Pennsylvani
American Poultry Advocate, Syracuse, N. Y.
American Poultry Journal, Chicago, Illinois.
Beet Sugar Gazette, Chicago, Illinois.
Belgrade Journal, Belgrade, Montana.
Better Fruit, Hood River, Oregon.
Big Timber Pioneer, Big Timber, Montana.
Billings Times, Billings, Montana.
Bozeman Chronicle, Bozeman, Montana.
Butte Inter-Mountain, Butte, Montana.
Chicago Daily Drovers' Journal, Chicago, Illin
Chicago Dairy Produce, Chicago, Illinois.
Chicago Markets, Chicago, Illinois.
Chinook Opinion, Chinook, Montana.
Coleman's Rural World, St. Louis, Missouri.
Cotton Seed, New York City, N. Y.
Daily Independent, Helena, Montana.
Dairy Record, St. Paul, Minnesota.
Dakota Farmer, Aberdeen, S. Dakota.
Dillon Examiner, Dillon, Montana.
Dillon Tribune, Dillon, Montana.
Elgin Dairy Report, Elgin, Illinois.
Farmers' Advocate, Winnipeg, Manitoba.
Fancy Fruit, North Yakima, Washington.
Farmers' Review, Chicago, Illinois.
Farmers' Tribune, Sioux City, Iowa.
Farm Home, Springfield, Illinois.
Farm Journal, Philadelphia, Pennsylvania.
Farm Life, Chicago, Illinois.
Farm Progress, St. Louis, Mo.
Farm News, Springfield, Ohio.
Farm and Stock, St. Joseph, Missouri.
Farm, Stock and Home, Mneapolis, Minnesot
Farm Poultry, Boston, Mass.

Feather, Washington, D. C.
Fruit Grower, St. Louis, Missouri.
Furrow, Moline, Illinois.
Gallatin County Republican-Courier, Bozeman, Montana.
Garden Magazine, New York, N. Y.
Gem State Rural, Caldwell, Idaho.
Gleanings in Bee Culture, Medina, Ohio.
Glendive Independent, Glendive, Montana.
Great Falls Weekly Tribune, Great Falls, Montana.
Havre Herald, Havre, Montana.
Hoard's Dairyman, Fort Atkinson, Wisconsin.
Home and Farm, Louisville, Ky.
Hospodar, Omaha, Nebr.
Independent, Miles City, Montana.
Illuminated World Life, Minneapolis, Minn.
Independent Farmer & Western Swine Breeder, Lincoln, Nebr.
Irrigation Age, Chicago, Illinois.
Jersey Bulletin, Indianapolis, Indiana.
Kansas Farmer, Topeka, Kansas.
Kimball's Dairy Farmer, Waterloo, Iowa.
Livingston Post, Livingston, Montana.
Madison County Monitor, Twin Bridges, Montana.
Madisonian, Virginia City, Montana.
Manhattan Record, Manhattan, Montana.
Market Growers' Journal, Louisville, Ky.
Milk River Valley News, Harlem, Montana.
Minnesota and Dakota Farmer, Brookings, S. Dakota.
Montana Homestead, Hinsdale, Montana.
National Grange, Philadelphia, Pennsylvania.
National Farmer, St. Louis, Missouri.
National Farmer, Winona, Minnesota.
Northwest Poultry Journal, Salem, Oregon.
Northwest Tribune, Stevensville, Montana.
Northwestern Stockman and Farmer, Helena, Montana.
Nut-Grower, Poulan, Georgia.
Orange Judd Farmer, Chicago, Illinois.
Oregon Agriculturalist, Portland, Oregon.
Pacific Coast Fancier's Monthly, San Jose, California.

Pacific Dairy Review, San Francisco, California.
Pacific Fruit World, Los Angeles, California.
Pacific Homestead, Salem, Oregon.
Pacific Poultryman, Seattle, Washington.
Poultry Herald, St. Paul, Minnesota.
Poultry Husbandry, Waterville, New York.
Practical Dairyman, New York, N. Y.
Prairie Farmer, Chicago, Illinois.
Reliable Poultry Journal, Quincy, Illinois.
Rocky Mountain Husbandman, Great Falls, Montana.
Republic, St. Louis, Missouri.
Rural New Yorker, New York, N. Y.
Semi-Weekly Missoulian, Missoula, Montana.
Southern Farm Magazine, Baltimore, Maryland.
Southern Farmer and Breeder, North Fort Worth, Texas.
Sugar Beet, Philadelphia, Pa.
Successful Farming, Des Moines, Iowa.
Sheep Breeder, Chicago, Illinois.
Successful Poultry Journal, Chicago, Illinois.
Stockgrowers' Journal, Miles City, Montana.
Terry Tribune, Terry Montana.
Town and Country Journal, San Francisco, California.
Tri-County News, Columbus, Montana.
Wallace's Farmer, Des Moines, Iowa.
Weekly Chroincle, San Francisco, California.
Western News, Libby, Montana.
World, Vancouver, B. C., Canada.

DONATIONS AND LOANS.

Miller-Tyson Company, Ohio, one Pasturizer.

Elo. Ericson, St. Paul, Minnesota, A weekly sample of lactic acid culture.

Marshall Dairy Laboratory, Madison, Wisconsin—Samples of cheese color and rennet tablets.

The following separator companies have loaned their latest pattern separators:

The Vermont Farm Machine Co., Bellows Falls, Vt.

The Empire Cream Separator Co., Bloomfield, N. J.

The DeLaval Separator Co., Chicago, Illinois.

The Omega Separator Co., Lansing, Michigan.

W. Atlee Burpee & Sons.—Numerous varieties of vegetable seeds.

Bolgiana & Sons, Baltimore, Maryland.—Two varieties of potatoes.

Mr. M. Langohr, Bozeman, Montana.—Ornamental plants.

W. M. Cooper & Nephews, Chicago, Illinois.—Gallon spraying material.

Stark Brothers, Louisiana, Missouri.—Several varieties of fruit trees.

METEOROLOGICAL REPORT—1907.

During the past year, as formerly, a record has been kept of air temperature, soil temperature, precipitation, humidity, wind velocity, wind direction, sunshine, and character of day, and all notes are transcribed in a book kept for that purpose. The Twelfth Annual Report defines the location and gives a description of the apparatus used. The Thirteenth Annual report gives a summary by months and years of the temperature, precipitation, character of day and prevailing wind direction for the years 1900 to 1906, inclusive. In order to keep the reports uniform, a like report for the year 1907 is here given.

YEARLY SUMMARY FOR 1907.

Highest temperature	84	Au. 8, 14 17.
Lowest temperature	-25	Jan. 14, 1907.
Greatest range for year	109	
Highest monthly mean	73.7	July, 1907.
Lowest monthly mean	2.8	Jan. 1907.
Highest daily mean	68.5	August 8, 1907.
Lowest Daily mean	-19	Jan. 14, 1907.
Mean temperature for year.....	40.8	
Greatest total pptn. for 1 mo.....	4.78	June
Least total pptn. for 1 mo .....	.36	Nov.
Total rainfall	18.2	in
Total snowfall	47.25	in.
First killing frost, Aug. 19.		
Last killing frost, June 14.		
Number of clear days in the year 1907	105	
Partly cloudy days	228	
Cloudy days	32	
Days with .01 inch or more pptn.	93	

WEATHER RECORD SUMMARY BY MONTHS

Months	Highest Tem.	Lowest Tem.	Mean Tem.	Precipitation	Snowfall	Cear Days	Partly cloudy	Cloudy Days	Days with .01 of an inch or more precipi- tation	Direction of prevail- ing Winds
Jan	45	—25	11.34	0.93	7.2	6	24	1	7	SW
Feb.	53	—14	29.0	0.80	8.5	12	12	4	4	SE
March	60	12	33.2	1.86	12.0	3	25	3	7	SW
April	67	11	37.98	0.59	8.8	8	21	1	6	SE
May	71	23	46.12	3.16		3	21	7	14	SE
June	77	33	52.2	2.78		5	23	2	17	SE
July	82	38	60.8	2.46		7	23	1	14	SE
Aug.	84	38	58.1	1.37		13	16	2	7	SW
Sept.	79	29	52.8	0.41		12	15	3	5	SE
Oct.	75	27	48.01	1.08		21	6	4	3	SE
Nov.	57	16	34.9	0.36	4.0	10	18	2	3	SW
Dec.	52	—5	25.7	.40	6.75	5	24	2	6	SE

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**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION.**

F. B. LINFIELD, Director.

FIFTEENTH ANNUAL REPORT.

FOR THE
FISCAL YEAR ENDING JUNE 30,
1908.

BOZEMAN, MONTANA
FEBRUARY
1909

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION.

BOZEMAN, MONTANA.

STATE BOARD OF EDUCATION

EDWIN C. NORRIS, *Governor*

A. J. GALEN, *Attorney General*

W. E. HARMON, *Sup't Public Instruction*

Ex-Officio

Helena

J. M. EVANS	.	.	.	.	.	.	.	Missoula
C. R. LEONARD	.	.	.	.	.	.	.	Butte
O. W. McCONNELL	.	.	.	.	.	.	.	Helena
O. P. CHISHOLM	.	.	.	.	.	.	.	Bozeman
S. D. LARGENT	.	.	.	.	.	.	.	Great Falls
G. T. PAUL	.	.	.	.	.	.	.	Dillon
E. O. BUSENBURG	.	.	.	.	.	.	.	Lewistown
CHARLES R. KESSLER	Helena

EXECUTIVE BOARD

WALTER S. HARTMAN, *President*

E. B. LAMME, *Vice-President*

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E. BROOX MARTIN

J. H. BAKER

Bozeman

Bozeman

Bozeman

Bozeman

Bozeman

GEO. COX, *Secretary*

STATION STAFF

F. B. LINFIELD, B. S. A., *Director*.

R. A. COOLEY, B. Sc., *Entomologist*

R. W. FISHER, B. S. *Horticulturist*.

E. TAPPAN TANNATT, B. S., *Rural Engineer*

W. J. ELLIOTT, B. S. A., *Dairyman*

ALFRED ATKINSON, B. S. A., *Agronomist*

ROBERT W. CLARK, B. Agr., *Animal Industry*.

EDMUND BURKE, B. S., *Chemist*

DEANE B. SWINGLE, M. S., *Assistant Botanist*.

J. B. NELSON, *Sup't. Dry Farm Work*.

H. O. BUCKMAN, M. S., *Assistant Agronomist*.

R. D. KNEALE, B. S., *Assistant Engineer*.

REUBEN M. PINCKNEY, B. S., A. M., *Assistant Chemist*.

Post Office, Express and Freight Station, Bozeman.

All communications to the Experiment Station should be addressed to

THE MONTANA EXPERIMENT STATION,

Bozeman, Montana

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

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AGRICULTURAL HALL

LETTER OF TRANSMITTAL.

Bozeman, Montana, December 31, 1908.

To His Excellency, Edwin L. Norris,
Governor of Montana.

Dear Sir: In accordance with the Congressional Acts of March 2, 1887, and March 16, 1906, I have the honor to transmit herewith the fifteenth annual report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1908, the results of investigations of the several departments are reported to the end of the state year, November 30, 1908.

Very respectfully,

F. B. LINFIELD,

Director.

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REPORT OF TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1907-1908:

	Hatch Fund	Adams Fund
Dr.		
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1908, under Acts of Congress approved Mar. 2, 1887, (Hatch Fund), and March 16, 1906, (Adams Fund).....	\$15,000.00	\$8,999.95
Cr.		
By Salaries	\$ 7,850.00	\$5,200.00
Labor.....	3,798.25	1,284.38
Publications.....	1,091.23	
Postage and stationery	393.24	14.25
Freight and express	218.28	108.47
Heat, light, water and power.....	103.04	
Chemical Supplies.....	171.17	351.99
Seeds, plants and sundry supplies.....	349.82	451.97
Fertilizers.....		
Feeding Stuffs		
Library	305.00	18.39
Tools, implements and machinery.....	122.02	242.93
Furniture and fixtures	196.89	41.50
Scientific apparatus	39.71	680.45
Live stock	30.00	
Traveling expenses	264.85	494.08
Contingent expenses.....	15.00	
Buildings and land	51.50	111.55
Balance.....		.04
Total.....	\$15,000.00	\$9,000.00

We, the undersigned, duly appointed auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of

the State of Montana, for the fiscal year ending June 30, 1908; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$5,000.00, and the corresponding disbursements \$2,417.13; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving a balance of \$2,582.87.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 20, 1906.

Signed

E. B. LAMME,

JOHN M. ROBINSON, Auditors.

Attest: GEORGE COX, Custodian.

EXPERIMENT STATION MISCELLANEOUS FUND.

Dr.	State	Individ- uals	Farm Pro- ducts	Total
To receipts from other sources than the United States for the year ended June 30, 1908.....	10,886.58	9,486.31	7,138.08	27,510.97
Cr.				
By Salaries		575.00	1,000.00	1,575.00
Labor.....	4,750.70	3,795.57	1,716.16	10,262.43
Publications	98.60		208.10	306.70
Postage and stationery	97.56	2.75	31.05	131.36
Freight and express.....	192.88	36.85	71.78	301.51
Heat, light, water and power.....	832.43		232.14	1,064.57
Chemical Supplies				
Seeds, plants and sundry supplies	1,795.80	162.38	238.06	2,296.24
Fertilizers				
Feeding stuffs	601.41		586.08	1,187.49
Library.....		2.50		2.50
Tools, implements and machinery	576.75	641.50	58.85	1,277.10
Furniture and fixtures				
Scientific apparatus	84.00		25.00	109.00
Live stock	55.00		1,093.84	1,448.84
Traveling expenses	784.44	923.56	14.75	1,722.75
Contingent expenses	375.98	635.17	1,421.45	2,432.60
Buildings and land	641.03	2,711.03	340.82	3,692.88
Balance				

REPORT OF THE DIRECTOR

The year 1907-08 has been an uneventful one in the work of the Montana Experiment Station. The work of the various departments has progressed satisfactorily, and valuable facts have been learned as a result of the year's work. The experiences of the year have emphasized previous lessons on the need for concentration of effort, though it has also shown the many obstacles to our endeavors in this direction. The yearly increase from the Adams fund for the past season has been used to provide an assistant in the chemical department. The major portion of the remainder was used to begin study upon a problem in the animal industry department.

With the expansion in the Experiment Station work, together with the increase in the students in all the agricultural courses, some definite plan in regard to the organization of the work for the future becomes necessary, and to a certain extent a division seems desirable between the work of teaching and experiment. A complete division has already been made between the teaching and research work in the chemical department. In the other departments it is probable that the heads will divide their time between teaching and experiment, but the assistants, in the main, will give their time wholly to teaching or wholly to Experiment Station work. This will enable the station work to be carried on with little loss incident to the breaking up of time, which the demands of the class room make necessary.

There is an increasing demand from all parts of the state for experiment and demonstration farms on the bench lands and under the various new irrigation ditches. With the many people coming to the state and settling on the land, both above and below the ditch, it would, I believe, be a most desirable and profitable undertaking for the state to invest in a large number of demonstration farms on the new irrigation projects, and also in those districts where large numbers are settling on the bench lands.

The past season was one of extremes of temperature and rainfall. In the south and central parts of the state the winter was dry, the spring late, and May and the early part of June the wettest I have seen in the west in sixteen years. As a wet spring always means

cool weather in this latitude, there was but little growth of spring crops till after the middle of June, and the following dry hot weather reduced the yields of the spring-sown crops on the College farm by at least 30%. The northern part of the state was cool and dry in the spring, but the eastern part had average weather. On the Station dry farms the crops on the whole were very good in all parts of the state.

IMPROVEMENTS

The completion of the new agricultural building, for which the legislature of Montana appropriated \$80,000.00, has provided greatly improved facilities for the agricultural work, both for the Station and the College. This building is 150 feet long and 68 feet in width, with a high basement (the floor of which is on a level with the ground) and two stories above. The construction is of pressed brick with sand stone trimmings and a tile roof. The inside finish is oak, with maple floors. The floor in the main entrance and in the basement hall is of terrazzo on reinforced concrete. All the heating, water and drainage pipes are in a sub-basement, which makes the basement floor just as desirable for class rooms or office as any other part of the building. The building is so arranged that greenhouses may be constructed against the south end of the building.

The main entrance faces the east. The south end of the basement is occupied by the horticultural department and the north end by the dairy department. The first floor affords space for the offices of the director, and the superintendent of farmers' institutes, library and reading room, and the offices, class rooms, and laboratories of the departments of agronomy and animal industry.

The second floor of the building is used by the domestic science department of the College, and is fully fitted up for this work.

SUB-STATIONS

The Northern Pacific and the Great Northern railroad companies have continued their subscriptions to the Station work, and four dry farm sub-stations have been maintained largely from funds so contributed. The stations have been maintained at the same places as the year before, except that the one at Shelby, in the northern part of the state has been discontinued.

In addition to these, two dry farm stations have been maintained by state appropriations: One near Great Falls and the other near the center of Fergus county, the latter being a permanent station. Considerable equipment has been added to the Fergus county station during the year, but much yet remains to be done to fully equip the farm.

Some very interesting and valuable results have been obtained as a result of the year's work, as will be noted in another place.

The horticultural sub-station near Corvallis, in Ravalli county, which was provided for by the Tenth legislature, has been started the past year. Twenty acres of land, with a water right, were deeded to the state of Montana by the Bitter Root Valley Irrigation Company. The law establishing this station required the donation of fifteen acres of land by the people of the valley. The Bitter Root Valley Irrigation company is to be commended for its generosity, as they not only gave the deed to fifteen acres but added five more for good measure, making twenty acres in all. They also afforded every facility for making a good selection as to soil and location, so that the Station has secured a very fine piece of land.

During the year the land has been fenced, the ground broken and most of the land planted to tree and bush fruits. The appropriation for this station was so small that no buildings and very little equipment could be provided. It is hoped that during the coming season funds will be available to fully equip the station.

About five years ago a small station was started some sixteen miles southeast of Great Falls, to test dry farm possibilities and winter irrigation from a small reservoir, built to catch the spring runoff. Two years ago, because of conditions as to help, this station was discontinued. The people of Great Falls, however, were very much interested in the work and during the past year have contributed about \$1,100 towards the equipment of a dry farm station about one mile from the city. The station has been in full operation during the past year. The people of Cascade county and the Experiment Station are much indebted to the Commercial Club of Great Falls, and especially to Messrs. T. L. Larkin and C. H. Campbell for their help and advice in connection with the Great Falls station.

CO-OPERATIVE EXPERIMENTS

The Northern Pacific and the Great Northern railroad compan-

ies have continued their support during the past year to the dry farm work carried on by the Station, the former contributing \$2500 and the latter \$2000 for the year, and in addition providing transportation for the men engaged and for the material used in the work.

At the Fergus county sub-station, which is devoted to dry farm tests, the Bureau of Plant Industry of the U. S. Department of Agriculture is co-operating with the Montana Station and giving material aid to the work.

On the Experiment Station farm at Bozeman co-operative experiments are being carried on with the Irrigation Division of the Office of Experiment Stations, U. S. Department of Agriculture. During the year a series of eight tanks has been provided by the irrigation division, and evaporation tests have been carried on by the agronomy department.

STATION STAFF

No changes were made in the Station staff during the past year. Mr. Edmund Burke, who had been assistant chemist for some years, was made chemist of the Station, and Mr. Reuben M. Pickney, a graduate of the University of Nebraska, entered on his duties as assistant chemist on September 1st, 1908.

AGRICULTURAL EXTENSION

The farmers' institutes continue to grow in interest and attendance. With a superintendent in charge of this work the Station men have been relieved to a considerable extent of the demands from this direction. We hope from this time to be able to so arrange this work that it may be a help rather than a burden to the Station staff, as I believe a certain amount of time in the institute field and in touch with the practical farmer, will be a help to the Station workers.

A new phase in the development of this work, during the past year, has been a course of lectures on agricultural topics at various high schools of the state.

CORRESPONDENCE

With the large number of new people coming to the state and with the expansion of the activities of the Station, the correspond-

ence continues to increase. During the year ending November 30, 1908, 5857 letters and 1687 circulars were sent out.

The letters from the various departments were as follows: Agronomy department, 749 letters and 287 circulars; Animal Industry department, 800 letters; Biological department, 600 letters; Chemical department, 150 letters; Dairy department, 880 letters and 800 circulars; Engineering department, 900 letters. From the Director's office were sent out 1218 letters and 600 circulars, and from the Farmers' Institutes, 560 letters.

LIBRARY

In the new agricultural building small but convenient quarters for the Station library have been provided. Bulletins of the various state experiment stations, and publications of the U. S. department of agriculture, to the number of 402 volumes, have been bound the past year. We have an almost complete list of these publications to date. These volumes comprise thousands of bulletins, reports and circulars. The Station has also the complete card index of station and department publications sent out by the Office of Experiment Stations.

In addition to the general library, several of the departments have fairly good collections of books dealing with the special problems of their work, and it is planned to add to these as rapidly as our funds will permit.

THE WORK OF THE DEPARTMENTS

There has been practically no change in the work of the various departments of the Station during the past year.

The Biological Department has continued to add to the data concerning the life histories of the insects affecting the sugar beet, and additional facts have been gleaned in regard to the diseases affecting apple trees. Valuable notes have been secured upon the predaceous enemies of grasshopper eggs, and some tentative laws are suggested relative to the cause of the sudden appearances and subsequent disappearance of insect pests. In the study of tree diseases it has been found that the canker of apple trees has intermittent periods of activity. A collar rot (so called locally) has been found to be caused by a definite fungus. A disease distinct from the pear blight has been found, which causes the death of pear trees.

New work has been started on the study of the wood tick, and a beginning has been made on a pest survey of the state.

The department has published one bulletin during the year.

The Agronomy Department has grown into the largest department of the Station. The dry farm work carried on at various stations over the state has given opportunity for gathering valuable experimental data. Much has also been accomplished in the line of a better knowledge of the crop possibilities of the various parts of the state, and these stations have been valuable object lessons to the farmers in the various communities.

A very large number of moisture and nitrate determinations have been made in connection with the study of the movement of moisture in the soil and the accumulation of nitrates in land cropped and uncropped. Some interesting and valuable information has been secured on these points. Observations have been carried out on both irrigated and non-irrigated land.

On the College farm, variety tests have been continued with small grains, clover, alfalfa, and other crops.

The irrigation tests on the duty of water, and the influence of varying amounts of water on the growth and ripening of the crops, have been continued. During the summer co-operative tests have been started to study the evaporation losses from irrigated land, and how these may be reduced to a minimum. This work has been taken up in co-operation with the Irrigation Division of the U. S. Department of Agriculture.

At the Fergus county sub-station variety tests of grain and fodders, and rotation tests, have been undertaken in co-operation with the Bureau of Plant Industry, U. S. Department of Agriculture.

The results of the year's work show that much of the dry bench lands promise to become valuable farm lands under proper methods of cultivation and cropping. They also show that with proper management the farmer has very large control over the moisture and nitrates in his soil.

The Horticultural Department.—The work of the horticultural department has been enlarged considerably during the year, due to starting the horticultural sub-station in the Bitter Root valley. As this sub-station is located in one of the best fruit sections of the

state, it is planned to carry on extensive variety tests of tree and bush fruits. Studies of methods of soil management in relation to fruit production and of the duty of water and other irrigation problems related to orchards are also contemplated. Some variety tests of vegetables will be conducted at this place.

At the College farm variety tests with fruit and vegetables have been continued. Good varieties of tomatoes, cabbage, celery, and onions, adapted to our higher valleys, have been determined, and some valuable plans worked out on how to handle those crops so as to get the largest returns.

Work has been continued with ornamental trees and shrubs, both native and introduced, and many of these promise well.

The Animal Industry Department has continued its feeding experiments with steers and hogs, these tests having been along lines similar to those of the previous year. Some maintenance experiments were begun with cattle and hogs, and also some tests on the grazing possibilities of an irrigated pasture for dairy cows.

To test the value of formalin as a preservative for skim milk, and to learn what effect varying amounts of formalin would have when fed with milk to young animals, a bunch of calves was fed with milk so treated. No conclusions have been drawn from any of these tests.

Some pure bred cattle and a small flock of pure bred sheep have been added to the live stock of the department during the year and will be available for future work in the department.

An experiment to learn the effects of methods of management and of breeding on the quantity and quality of the wool of fine woolled sheep has also been started during the year.

The Dairy Department has continued its studies on the use of the milking machine, but the major portion of the work of the department has been along extension lines. Two circulars, one on the milking machine and the other on the manufacture of cheese, have been issued during the year, and considerable time has been given to the inspection of creameries and to fitting out and directing a dairy train to give instruction in some of the promising dairy districts of the state.

The Chemical Department.—During the year an assistant has been added to the chemical department, which increased greatly the

amount of work the department turned out. The department has given the greatest part of its time to two special problems: First, to discover the actual conditions as to temperature, moisture and carbon dioxide surrounding hens' eggs during natural and artificial incubation. A special electric thermometer has been added to the equipment for this work during the year. The other problem of the department was a study of Portland cement, and the effect of alkali on the same; this problem being taken up in co-operation with the engineering department. The chemical agent most active in disintegrating the cement has been located, but the exact changes that take place have not been worked out.

In addition to the above the department has made a large number of analyses for other departments of the Station.

For agronomy department, moisture demonstrations have been made on 28 samples of straw and grain. The total nitrogen was determined in 85 samples of soil and nitrates. Nitrites and ammonia was determined in 413 samples.

For the animal industry department complete analyses have been made of 15 samples of grain and 15 samples of feces, requiring 180 determinations.

For the engineering department 5 samples of soil and water and four samples of cement were analyzed.

For the horticultural department 19 samples of soil were analyzed, requiring 95 determinations.

A large number of analyses of a miscellaneous character come to the department, but the endeavor is to reduce these to a minimum. There have been made during the year a few more than 40 such analyses, including samples of clays, soils, gypsum, coal, food stuffs, etc. The policy is to confine these analyses to samples connected with agricultural work; and to gather such information about the samples as will, in time, with the accumulation of the data, have value in our study of the soils and agricultural products of the state.

The Poultry Work is supported wholly from state and income funds. During the past year a graduate of the Maine University, who had given special study to the poultry work, has been placed in charge of the poultry plant. Our problem is to build up the poultry plant and to study the conditions favorable to economic poultry keeping in Montana.

The Engineering Department.—The seepage and drainage problem, undertaken two or more years ago, has occupied practically all the time of the engineering department during the past year. Some valuable conclusions have been reached as a result of the seepage studies and these are published in Bulletin No. 76. In the same bulletin are given some practical methods for the economic drainage of lands that have become excessively wet from seepage water.

Studies of the effect of alkali on Portland cement, taken up in connection with the seepage studies, have shown conclusively that the alkali will break down and destroy cement. The most active constituent of the alkali has been determined and some light thrown on the cause of the disintegration. A bulletin is soon to be issued on the results of these studies.

In addition to the above, the department has made some observations on the practical use of water measuring devices for irrigation canals and ditches, and has issued a revised edition of Bulletin No. 34, embodying these special studies.

MAILING LIST

For the past two or three years the Experiment Station mailing list has increased by nearly 1,000 names a year. We are now publishing an edition of 8,000, but will probably have to increase this to 9,000 next year.

About 4,000 copies are distributed to the farmers of the state some 911 copies are sent to people in other states, 102 to foreign countries, and about 2200 copies to the officers of the various state experiment stations and to the U. S. Department of Agriculture. This leaves a surplus of about 1,000 copies to supply future calls.

PUBLICATIONS OF THE YEAR

For the year 1907-08 five bulletins and the fifteenth annual report have been published. These contain 186 pages of printed matter, 35 full page plates and 4 double page plates.

Bulletin No. 72.—**Measurement of Water**, by E. Tappan Tannatt, rural engineer, and R. D. Kneale, assistant engineer. This bulletin supplements Bulletin No. 34 on the same topic, which is out of print. It calls especial attention to some serious errors in

measurement that result from misplaced weirs, and gives additional information on methods of placing measuring weirs in canals and ditches. Very full tables are given showing the discharge of Cippoletti weirs of different lengths expressed in Montana miners' inches, and in cubic feet per second; also tables on the discharge of farmers' weirs. It contains 40 pages and eleven plates.

Bulletin No. 73.—**Pig Feeding Experiments**, by F. B. Linfield. This is a series of eight experiments, carried on during three years, to test the value of various supplementary foods when fed with a grain ration in fattening pigs; 19 pages.

Bulletin No. 74.—**Dry Farm Investigations in Montana**, by Alfred Atkinson, agronomist, and J. B. Nelson, superintendent of dry farm sub-stations. This bulletin presents the results of three years experiments on the dry farm sub-stations, and gives the yields of the various crops under various systems of soil and crop management. It contains 30 pages and 10 plates.

Bulletin No. 75.—**The Sixth Annual Report of the State Entomologist**, by R. A. Cooley, entomologist. This bulletin calls attention to some observations carried on with the wood tick, and outlines some future studies to be taken up. This work grew out of the relation of the tick to the disease known as Rocky Mountain spotted fever. The second chapter of this bulletin gives a description of the Glover silk moth (*Samia gloveri*, Strecker.) This bulletin has 20 pages and 2 plates.

Bulletin No. 76.—**Seepage and Drainage (Part II)**, by E. Tappan Tannatt, rural engineer, and R. D. Kneale, assistant. This bulletin gives the results of experiments and observations on seepage losses from irrigation canals, and describes methods of reclaiming lands made excessively wet by seepage water under the peculiar sub-soil conditions prevailing in various valleys in Montana. This bulletin has 56 pages, 8 single page plates and four double page plates.

The Fifteenth Annual Report.—This is the Director's report on the work of the year, calling attention to the improvements made and to the work of the various departments. The meteorological report for Bozeman, for the past year, is included in the report. It contains 32 pages and one plate.

LIST OF STATION PUBLICATIONS AVAILABLE FOR DISTRIBUTION

1. Organization—Announcements.
2. Smuts of Wheat, Oats and Barley.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
35. Report of Feeding Tests.
36. Forage Conditions in Montana.
37. Pork Production in Montana.
38. Food Adulterations.
40. Root Crops in Montana.
41. Sugar Beets, (1902.)
42. The Codling Moth.
Ninth Annual Report.
44. Apple Growing in Montana.
45. The Loco, and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
51. First Annual Report of the State Entomologist.
52. Sugar Beets.
53. Creameries and Cheese Factories.
55. Second Annual Report of the State Entomologist.
62. Third Annual Report of the State Entomologist.
67. Practical Beekeeping.
68. Canadian Field Peas.
69. The Effect of Alkali on Portland Cement.
70. The Douglas Fir Cone Moth.
71. The Fifth Annual Report of the State Entomologist.
The Fourteenth Annual Report.
72. Measurement of Water.
73. Pig Feeding Experiments.
74. Dry Farming Investigations in Montana.
75. The Sixth Annual Report of the State Entomologist.
76. Seepage and Drainage.
The Fifteenth Annual Report.

DONATIONS AND LOANS

- Stark Bros., nurseries, Louisiana, Mo., fruit trees.
- C. G. Patten, nurseries, Charles City, Ia., fruit trees.
- W. Atlee Burpee & Co., Philadelphia, Pa., garden seeds.
- Rex Lime Sulphur Co., Omaha, Neb, 5 gallons lime sulphur solution.
- Kentucky Tobacco Product Co., Louisville, Ky., 5 gallons "Tobacco-Leaf Extract."
- Perfection Churn Co., Owatonna, Minn., 1 Perfection churn.
- Jensen Manufacturing Co., Topeka, Kas., 1 Jensen cream ripener.
- Creamery Pkg. Mfg. Co., Minneapolis, Minn., 1 Wizzard agitator.
- Vermont Farm Machine Co., Bellows Falls, Vt., 1 No. 6 U. S. hand separator.
- Vermont Farm Machine Co., Bellows Falls, Vt., 1 No. 15 U. S. hand separator.
- DeLaval Separator Co., Chicago, Ill., 1 No. 17 DeLaval separator.
- Omega Separator Co., Lansing, Mich., 1 Omega hand separator.
- Currie Hardware Co., Mason City, Ia., 1 Eclipse moisture test.
- Elov. Ericsson, St. Paul, Minn., 1 year's supply Butter Culture.
- The Marshall Dairy Lab., Madison, Wis., rennet and color samples.
- Frank L. Jones, Utica, N. Y., rennet and pepsin samples.
- Dairy Specialty Co., West Chester, Pa., 1 2-bottle Babcock tester.
- J. Frank Smith, Pleasanton, Kas., 1 book "Eby's Handy Tables."
- D. H. Burrell Co., Little Falls, N. Y., 1 milking machine equipment, complete for use in the Dairy Special.
- The use of coach and baggage car from the Northern Pacific R. R. for dairy demonstrations across the state.
- City of Great Falls, cash for use in alkali-cement investigations, \$75.00.
- Cascade county, cash for use in alkali-cement investigations, \$50.00.
- A. E. Wheeler, Great Falls, Montana, cash for use in alkali-cement investigations, \$25.00.
- Kenyon-Noble Lumber Co., Bozeman, Mont., 1 barrel Ideal cement.
- Utica Hydraulic Cement Co., Utica, Ill., 1 barrel cement.
- Standard Portland Cement Corporation, San Francisco, Cal., 1 barrel cement.
- Glenns Falls Portland Cement Co., Glenns Falls, N. Y., 1 barrel Iron Clad cement.
- The Portland Cement Co., Portland, Col., 1 barrel Ideal cement.

Lesley & Trinkle Co., Philadelphia, Pa., 1 barrel Giant cement.

Peninsular Portland Cement Co., Jackson, Mich., 200 lbs. cement.

Northwestern States Portland Cement Co., Mason City, Ia., 1 barrel Northwestern cement.

The Atlas Portland Cement Co., New York city, 1 barrel cement.

U. S. Reclamation Service, Fort Shaw, Mont., 200 lbs. Marquette cement.

Penn-Allen Cement Co., Allentown, Pa., 1 barrel cement.

Lehigh Portland Cement Co., Mitchell, Ind., 1 barrel cement.

Western States Portland Cement Co., Independence, Kan., 1 barrel cement.

Virginia Portland Cement Co., Fordwick, Va., 1 barrel Old Dominion cement.

Alsen's American Portland Cement Works, New York city, 1 barrel cement.

Hudson Portland Cement Co., N. Y., 1 barrel Hudson cement.

Universal Portland Cement Co., Chicago, Ill., 1 barrel Universal cement.

Miracle Pressed Stone Co., Minneapolis, Minn., 1 sack R. O. U. cement waterproofing.

Aquabar Co., Philadelphia, Pa., 1 pint "Aquabar."

Miracle Pressed Stone Co., Minneapolis, Minn., 1 tile making (cement) outfit.

METEOROLOGICAL REPORT

Months	Highest Temperature	Lowest Temperature	Mean Temperature	Precipitation	Snowfall, inches.....	Number of Clear Days.....	Number of Partly Cloudy Days.....	Number of Cloudy Days.....	No. of days with .01 of an inch or more of precipitation.....	Prevailing Wind Direction...
January	45	-15	23.3	.52	12	17	13	1	5	E. S.
February	50	-20	24.9	1.27	20	11	15	3	8	E. S.
March	59	0	28.6	1.40	20.7	9	15	7	9	W. S.
April	76	-1	42.9	1.36	19	14	15	1	9	W. S.
May	75	31	45.9	9.54	8	8	13	10	15	E. S.
June	88	33	52.6	4.57	—	8	20	2	17	E. S.
July	91	35	65.4	.32	—	17	14	0	5	E. S.
August	94	32	60.8	1.09	—	12	17	2	7	E. S.
September	86	22	55.3	1.12	9	15	12	3	5	E. S.
October	72	9	40.0	1.97	20	10	15	6	6	E. S.
November	63	0	33.6	.35	5	..10	17	3	4	E. S.
December	45	-13	22.3	.36	6.5	2	15	14	4	E. S.

YEARLY SUMMARY FOR 1908.

Highest temperature..... 94°, Aug. 1.
Lowest temperature -20° Feb. 1.
Greatest range 114
Highest monthly mean 65.4, July.
Lowest monthly mean 22.3, Dec.
Highest daily mean 75, Aug. 1.
Lowest daily mean..... -8, Feb. 1.
Mean temperature for year..... 41.3.
Greatest total pptn. for 1 month.....9.54 in. May.
Least total pptn. for 1 month..... .32 in. July.
Total rainfall23.87.
First killing frost Aug. 26th.
Last killing frost May 26th.
Number of clear days in year.....133.
Number of partly cloudy days in year.....181.
Number of cloudy days in the year..... 52.
Days with .01 or more of pptn..... 94.

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**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION**

F. B. LINFIELD, Director.

Sixteenth Annual Report

FOR THE FISCAL YEAR ENDING JUNE 30, 1909

BOZEMAN, MONTANA.

FEBRUARY, 1910.

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION.

BOZEMAN, MONTANA.

STATE BOARD OF EDUCATION

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A. J. GALEN, *Attorney General*

W. E. HARMON, *Sup't Public Instruction*

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STATION STAFF

F. B. LINFIELD, B. S. A., *Director.*
R. A. COOLEY, B. Sc., *Entomologist*
ALFRED ATKINSON, B. S. A., *Agronomist*
ROBERT W. CLARK, B. S. A., *Animal Industry.*
EDMUND BURKE, B. S., *Chemist*
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W. J. TAYLOR, D. V. M., *Veterinarian*
J. B. NELSON, *Superintendent Dry Farm Work.*
REUBEN M. PINCKNEY, B. S., A. M., *Assistant Chemist.*
L. F. GIESEKER, B. S., *Assistant Agronomist.*
WM. F. SCHOPPE, B. S., *Assistant Poultryman.*
W. W. SPAIN, B. S., *Assistant Dry Farming.*
H. E. MORRIS, B. S. *Assistant Botanist.*
H. P. GRIFFIN, B. S., *Assistant Animal Industry.*
R. C. JONES, B. S., *Assistant Dairyman.*
N. B. LUNDWALL, *Clerk.*

Post Office, Express and Freight Station, Bozeman.

All communications to the Experiment Station should be addressed to

THE MONTANA EXPERIMENT STATION,

Bozeman, Montana

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

LETTER OF TRANSMITTAL

Bozeman, Montana, December 31,
To His Excellency, Edwin L. Norris,
Governor of Montana.

Dear Sir:

In accordance with the Congressional Acts of March 3, 1887, and March 16, 1906, I have the honor to transmit herewith the Sixteenth Annual Report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1909; the results of investigations of the several departments are reported to the end of the state year, November 30, 1909.

Very respectfully,

F. B. LINFIELD, Director

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REPORT OF TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1908-1909:

Dr.		Hatch Fund.	Adams Fund.
To balance from appropriations for 1907-1908			.04
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1909, under Acts of Congress approved March 2, 1887, (Hatch Fund) and March 16, 1906, (Adams Fund)	\$15,000.00	\$10,999.96	
Cr.			
By salaries.....	\$ 7,050.00	\$ 6,300.00	
Labor	3,915.87	2,222.41	
Publications	1,179.87		
Postage and stationery	592.17		
Freight and express	188.86		
Heat, light, water and power.....	91.06		
Chemical supplies	189.29		
Seeds, plants and sundry supplies.....	386.89		
Fertilizers	25.00		
Feeding stuffs	285.10		
Library	171.41		
Tools, implements and machinery.....	156.65		
Furniture and fixtures	455.94		
Scientific apparatus	19.29		
Live stock.....	2.00		
Traveling expenses	173.10		
Contingent expenses.....	15.00		
Buildings and land.....	102.50		
Balance			
Total	\$15,000.00	\$1	

We, the undersigned, duly appointed auditors of the
tion, do hereby certify that we have examined the books

counts of the Experiment Station of the Agricultural College of the State of Montana, for the fiscal year ending June 30, 1909; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$5,000.00, and the corresponding disbursements \$2,417.13; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving a balance of \$2,582.87.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 20, 1906.

Signed:

J. H. BAKER.
WALTER S. HARTMAN.
Auditors.

Attest: George Cox, Custodian.

EXPERIMENT STATION MISCELLANEOUS FUND.

Dr.	State	Individ- uals.	Farm Products.	Total
To receipts from other sources than the United States for the year end- ed June 30, 1909.....	\$10712.99	\$4561.49	\$5090.27	\$20364.75
Cr.				
By salaries.....		200.00		200.00
Labor	5,756.69	3,285.96	1,690.62	10,733.27
Publications	551.20			551.20
Postage and Stationery.....	218.53		.25	218.78
Freight and express.....	107.89	27.00	26.93	161.82
Heat, light, water and power.....	1,409.87		59.67	1,469.54
Chemical supplies.....				
Seeds, plants and sundry supplies..	858.58		253.47	1,112.05
Ferterlizers				
Feeding stuffs.....	884.41		147.64	1,032.05
Library	102.00			102.00
Tools, implements and machinery..	210.32		190.00	400.32
Furniture and fixtures.....	20.70		81.50	102.20
Scientific apparatus.....	180.00			180.00
Live Stock.....	204.50		579.97	784.47
Traveling expenses.....	15.90	1,048.53	83.25	1,147.68
Contingent expenses.....			1,749.03	1,749.03
Buildings and lard.....	192.40		227.94	420.34
Balance			227.94	
Total	\$10,712.99	\$4,561.49	\$5,090.27	\$20,364.75

REPORT OF THE DIRECTOR.

THE INCREASED SUPPORT FOR THE EXPERIMENT STATION.

The past year was one of material progress in the work and equipment of the Experiment Station. At the beginning of the year the Agricultural Building was completed and the technical agricultural department moved in during the Christmas holidays. The improved facilities have permitted much better organization of the work of the department.

The state legislature, which met during January and February, 1909, continued its generous support to the work of the Experiment Station. The fund for general maintenance was increased from \$7,500 per year to \$12,500 per year. Nine thousand dollars per year was given for the work of the temporary dry farm stations and \$2,000 per year for the maintenance of the permanent dry farm station in Fergus county, and \$1,250 per year for the maintenance of the horticultural substation in Ravalli county. This was a total increase of \$7,250 over the appropriation of the year before.

For improvements the Station received \$10,000 for farm improvements at the home station; \$5,000 for improvements at the dry farm sub-station, and \$3,000 for the horticultural sub-station. Arrangements were also made for the purchase of 160 acres of irrigated land adjoining the present station farm on the west, from the college endowment fund. This practically doubled the area of the station farm. During the year the governor of the state made the director of the station custodian of the Fort Ellis reservation, a tract of 640 acres, for the use of the Experiment Station. This is a tract suitable for dry farm work, but it will also afford some opportunities for fall, winter and early spring irrigation.

The Station is also indebted to the railways of the state for generous support for dry farm work carried on over the state. The Northern Pacific railway donated \$5,000 for the year, the Great Northern railway \$2,000, and the Chicago, Milwaukee & Puget Sound railway \$2,000. All these railroads have also given transportation to the Station officers, who were carrying on work out over the state. This generous support for the dry farm work has enabled us to extend and make more thorough the dry farm studies.

During the year substantial progress was made towards the organization outlined in my last report and the concentration of the work of the departments. The work in agricultural engineering was made an assistant division of the agronomy department. The head of the agronomy department now gives three-fourths of his time to the Station work. One assistant gives all of his time to the College. Three assistants are engaged in the Experiment Station.

On the first of September, 1909, a department of veterinary science was organized, the head of the department to give one-half his time to Station work.

In the animal industry department, an assistant was added who gives two-thirds of his time to the Station, and late in the season, with the resignation of the professor of dairying, the dairy work was made a sub-division of the animal industry department.

THE AGRICULTURAL PROGRESS OF THE STATE

Ten years ago, had any person suggested that the prairie bench lands of Montana would be farmed, he would have been laughed at by most of the people of the state and to have advocated their settlement would, by the many, have been thought to be criminal. However, with the passing of the years and with the study during the past five years of dry farm methods, culminating last October in the Dry Farm Congress at Billings, the people of the state and the business interests of the state have awakened to the agricultural possibilities of Montana's bench lands and people from all over the country have been invited to come and take possession of the last free homestead land of the Northwest. This invitation has met with a surprising response and if we may judge from the land filings as reported from the various U. S. Land Offices, within a very few years all the available bench lands susceptible of cultivation will have passed into the hands of the farm settler and the 20,000,000 acres or more of bench farm lands will be turned into cultivated fields.

A few years ago it was thought that the entry of the Federal government in the irrigation development of the West would check or discourage private enterprises in this development. In Montana the opposite effect appears to have been induced; it has appeared to stimulate private enterprise, as never before has such

irrigation development been going on, and a few years more will double if not treble the area of land under the ditch as compared with six to seven years ago. On many of the irrigated projects intensive farm methods are being encouraged. Orchards, sugar beets and the dairy are receiving more and more attention. Only a start has yet been made but the promise for the future is most encouraging. Our public men are beginning to think and talk of Montana as a great agricultural state.

THE EFFECT OF THE AGRICULTURAL DEVELOPMENT ON THE EXPERIMENT STATION.

But all of this agricultural development, the coming of this multitude of people to take up a new agriculture in a new country, places a large responsibility on the state and upon the Experiment Station. Our results go to show conclusively that when proper methods of soil management and cropping are followed, large and profitable crops may be grown. But the man who does not understand the peculiar conditions he will have to meet, or who is careless or indifferent, is going to fail or have only a partial success, whether he is above or below the ditch. It will be our endeavor as far as our means and time will permit, to inform the ignorant, to furnish definite facts to the inquirers and to stimulate the careless and indifferent. We will endeavor to the best of our ability, to extend our knowledge and control over nature as manifested under Montana conditions in so far as these will be of help to the farmer, so that he may build here a successful agriculture, enjoyable and progressive. From the standpoint of the investigator the field is large and it is most inviting, but the problems are very intricate.

As is indicated above, the demands upon the Experiment Station are increasing rapidly. The dry land demonstration farms have been doubled during the year. The development of the fruit industry is very largely increasing the problems and the work for the horticultural and biology departments. The letters sent in for information about Montana and Montana agriculture are double those received one year ago. While the demands of the work already undertaken are increasing rapidly, there is yet need for the inauguration of other lines. There is need and a demand for a

soil survey of the state. Because of the great variety of surface, the mountain, the valley and the plain, the state presents a great variety of soil types. It would be a very great help to the future agricultural development of the state if the soil types could be studied, classified and mapped. It would take a small corps of thoroughly trained men several years to accomplish the work. But the irrigated and the thoroughly farmed areas could first be studied and the cheaper and more remote lands taken up later. Eight thousand to ten thousand dollars a year would inaugurate this work and put it on an efficient basis.

With the settling up of the prairie bench lands there is going to be a pressing need for forestry studies as adapted to the farm. At least three things should be considered in commencing this work. These prairie homes need the protection which a tree plantation would give from wind and storm; the farmer also needs and is going to need fence posts and timber and in the third place a growing wood supply is going to be increasingly valuable as years go by. On the dry bench lands the problem is to find the varieties that will be suitable and yet thrive, to find the system of planting best suited to the peculiar condition of the bench farm and next, what method of soil management will be necessary to successful vigorous growth. In this work both trees and shrubs should be considered.

When started in any place, work of this kind should be continued for at least ten years and studies should be made in the various climatic zones of the state. It is planned to make a beginning in the work during the coming year at the Fergus county substation.

IMPROVEMENTS.

The last legislature appropriated \$18,000 for use in building and improvements by the Experiment Station; \$10,000 of this was for buildings at the central station and \$8,000 for buildings and equipment at the substations. It was expected that this fund would have been available the past year, but as a shortage in state funds was feared, the appropriation was not made available till the end of the year. Plans are under way for the construction of the buildings during the coming season.

During the year, from general funds, the dairy building has been fixed up and made suitable for the work in veterinary science. The biological department has taken possession of all of the old Experiment Station building and remodeled it to suit the work of the department. The dairy department has moved into and fully equipped its quarters in the new Agricultural building. In addition to the above, a large amount of new fencing has been built, enclosing and dividing new pastures. In these improvements, the cost of which was shared by the College and Experiment Station, about \$1500 was spent.

SUBSTATIONS.

The work of the Fergus county sub-station was fully organized and started during the past season. Some 400 plats were in use for the experiment work, covering 80 acres. The work was somewhat hampered by the failure to obtain the funds appropriated for improvements. However, the maintenance fund was increased by the legislature from \$1,000 to \$2,000 per year, which enabled us to carry out the plans for the year's work. We have started at this place several series of experiments which we hope in time will prove of large value in finding new varieties of grain better adapted to dry farm conditions, and new methods of cropping and crop management, which will give permanency to our dry farm agriculture.

Considering the permanent character of the work here started and its importance to dry land agriculture in the state, it would be of great advantage if the 200 acres adjoining the substation and belonging to the State School grant could be joined to the station farm permanently. This may be done by the purchase of the land by the state or perhaps by a permanent lease at a nominal sum. The full equipment of this place will yet call for some additional funds.

For the horticultural substation in Ravalli county the legislature increased the maintenance by \$250 per year and gave \$3,000 for further equipment and improvements. As this latter sum was not available the past year, nothing more was done than to maintain the work already started at this place. Fruit trees have been planted on fifteen acres.

Dry farm studies on the temporary substations have been continued during the year. The value of this work as a demonstration

of the farm possibilities of the district is being fully recognized and made use of by the people, and it affords the station an opportunity to get thoroughly acquainted with soil conditions and crop possibilities in very many parts of the state.

The increased funds given by the state and the railways permitted us to start several temporary dry farm substations the past year, so that now thirteen stations are in operation. These stations are located as follows: Aided by the Northern Pacific railway—At Adams, thirty miles north of Glendive; at Terry (two stations); at Forsyth and in the Lake Basin, north of Billings. Aided by the Great Northern railway—At Great Falls; at Chester and about twenty-five north of Harlem. In co-operation with the people of the towns, stations were directed near Fort Benton and Havre. Aided by the Chicago, Milwaukee & Puget Sound railway—At Baker and at Roundup. A station was also started near Dillon in Beaverhead county. At each of these stations about forty acres are cropped. The results the past year have been above the average for the previous years of this work. These stations have proved valuable educative aids for the people of the localities and especially to the new settler. At several of the stations Farmers' Institute meetings were held just before the crop was harvested and the crops afforded a very fine illustration of the effect of different methods of soil and crop management followed.

CO-OPERATIVE EXPERIMENTS.

During the year we have been able to very much extend our work owing to the co-operation and help of the railways of the state and of the U. S. Agricultural department. Five dry farm substations in various parts of the state have been maintained through the aid and co-operation of the Northern Pacific railway. Three have been maintained by help from the Great Northern railway and two dry farm sub-stations we owe to the support of the Chicago, Milwaukee & Puget Sound railway. These local substations enable us to study a great variety of local conditions and their adaptability to dry farm agriculture.

At the Fergus substation we are co-operating with the Bureau of Plant Industry, United States Department of Agriculture, in the study of : first, crop rotations adapted to the dry farm ; second, grain

varieties suitable for the Montana dry farm, and, third, fodder and pasture crops that may be used by the dry farmer.

On the home station at Bozeman, we are carrying on some studies with soil mulches for irrigated ground in co-operation with the Irrigation Division of the Office of Experiment Stations, United States Department of Agriculture.

Our entomological department has taken up some studies in the Bitter Root valley in this state in co-operation with the Bureau of Entomology of the U. S. Department of Agriculture. They are investigating the life history of the wood tick and its relation to spotted fever.

STATION STAFF.

In taking up the work which the agricultural development of the state is bringing to us, I consider that the state and the Experiment Station is indeed fortunate in its corps of agriculture investigators, men in whom the scientific spirit predominates, and I wish to commend the loyalty and the harmonious co-operation which characterizes the work of each member of the station staff.

At the beginning of the school year, July 1st, some important changes were made in the station staff. Two of the heads of departments resigned to take up commercial work at greatly increased salaries. Professor E. T. Tannatt, who was in charge of the rural engineering work of the station, entered on his work with the station in September, 1905, and during his connection with the station carried through some valuable experiments.

Professor R. W. Fisher, Horticulturist, was connected with the Station since 1901. His eight years of service had made him very well acquainted with the horticultural problems of the state and thus of great value to this work.

Later in the season, Prof. W. J. Elliott, who had charge of the dairy work, resigned to accept a more lucrative position in Canada. During his six years connection with the Station, Professor Elliott had built up a well equipped department.

In view of the above resignations it was thought best to rearrange in some directions and to concentrate the work. As our problems in irrigation are closely related to agronomy, it was decided for the present to make the Rural Engineer an assistant to this department and Mr. W. W. Spain, a graduate of the College, was

engaged as assistant agricultural engineer in the agronomy department to give his whole time to station work.

The dairy work was put under the direction of the animal industry department and an assistant in dairying will be engaged to look after this work. With the beginning of the school year, an assistant in animal industry, Mr. H. P. Griffin, of Columbia, Missouri, was engaged. He gives two thirds of his time to station work.

In the biological department, Mr. Elwood H. Morris was engaged as assistant botanist, giving his whole time to investigations in the botanical division of the work.

Professor O. B. Whipple, who was in charge of the Colorado Horticultural substation at Grand Junction, Colorado, was engaged to take charge of the horticultural work of the station. He began work on July 1st, 1909.

During the year a new department was added to the station, viz., veterinary science. Dr. W. J. Taylor, a graduate of Cornell University Veterinary College, was engaged to take charge of this department and entered on his duties on September 1st, 1909.

AGRICULTURAL EXTENSION.

FARMERS' INSTITUTES.

The interest in the Farmers' Institute work has continued to grow during the year. With a superintendent in full charge of this work, the demands on the station staff have not been as great as formerly, but there are yet many special calls which it is impossible to disregard. The last legislature increased the funds for this work by \$500 per year.

A new feature of the work of the year was a series of lectures on some phase of agriculture at several high schools of the state. These lectures were very well received and will be continued next year.

CORRESPONDENCE.

The correspondence of the station continues to increase. During the year ending November 30, 1909, 7237 letters and 9850 circulars were sent out. These were distributed as follows among the

various departments: Dairy department, 1019 letters and 3000 circulars; Animal Industry department, 640 letters and 500 circulars; Poultry department, 400 letters and 300 circulars; Agronomy department, 1163 letters and 3200 circulars; Biology department, 910 letters; Horticultural department, 521 letters; Chemical department, 99 letters,. From the Director's office were sent out 1500 letters and 450 circulars, and from the Farmers' Institute office 985 letters and 2400 circulars.

WORK OF THE DEPARTMENTS.

During the past year we have attempted to organize the records of the experimental work of the Experiment Station on a better basis. A list of the experiments carried on by each department has been prepared and a full description of the plans of the work has been filed in the office of the Director. It is hoped by this means to keep in close touch with the work of each department and to keep informed of the progress of each project undertaken.

The Biological Department: With the increase of the fruit industry of the state we find that the enemies of the fruit are multiplying. The older pests of the east here present a new problem, while we have some problems which appear to be peculiar to ourselves. The pests and diseases of the fruit are in no wise as bad as in most eastern sections and up to the present have been kept fairly well under control. The biological department is giving its best endeavors to help our fruit growers to maintain these favorable conditions.

In addition to the usual routine work, the entomologist of the department has given the most of his time to two or three projects. In the study of the oyster shell scale some definite practical results were obtained and a very promising new treatment for this insect has been found. The studies on sugar beet insects have been continued and considerable additional data gathered on the several species. Some preliminary studies and observations were made on the wood tick in the Bitter Root valley, where it is believed to have some relation to the spread of spotted fever. This work was preparatory to more extended studies contemplated for the coming year.

The plant physiology and bacteriological division of the biology science was started September 1st, 1909, when Dr. W. J. Taylor

work has continued the studies of its two main problems, viz., "Bark and wood diseases of orchard trees," and, 2nd, "The effect of arsenic on vegetation." The second problem is in a measure an outgrowth of the first as the description of the injury reported from other stations as due to arsenic had been observed in Montana where no arsenious sprays had been used.

Substantial progress has been made in studying the diseases of orchard trees but not sufficient information has been gathered to warrant any definite conclusions. Studies with the pear blight seem to indicate that treatments that work out in other places seem to leave some loop-hole for the spread of the disease under Montana conditions. A circular on the general treatment of this disease was issued during the year.

The studies on the effect of arsenic on vegetation were only started during the year and in the main were confined to greenhouse studies. Some valuable and interesting information has been gained, but much work yet remains to be done.

The Agronomy Department: The agronomy department was strengthened during the year by appointment of an assistant for the College work. The head of the department now gives three-fourths of his time to the Experiment Station.

The work of the Agronomy department covers five general divisions.

1st. Crop and soil studies on the irrigated land at the home station

2ud. Crop and soil studies on the dry land at the Fergus county sub-station

3rd. Dry farm studies at some eleven substations in various parts of the state

4th. Special studies on nitrates and moisture of the soil under dry farm and irrigated conditions

5th. Agricultural engineering studies with special problems in seepage and drainage.

The season was not particularly favorable for crop studies, yet substantial progress was made in all departments of the work. The crop and soil studies on the station farm have been located on a piece of land which is believed to be very uniform in depth and quality and several new projects have been taken up. At present some forty acres of irrigated land are being used for this work and

about 520 plats are being used. In this division of the agronomy work, sufficient data has been gathered for two bulletins; one on alfalfa and the other on grain varieties and these it is planned to prepare in the near future.

The past season saw the cropping work fully inaugurated at the Fergus county sub-station. The season was one of excess of rainfall at this place. The crops were very good, but no conclusions can be drawn from the work here for several years.

At the dry farm substations over the state opportunity has been afforded to study many local conditions and also seasonal climatic variations in the various parts of the state and the effect of these upon the crop yield.

The special studies on the nitrates and moisture of the soil have been continued during the year and it is believed that some interesting and valuable data have been gathered. This material is being studied during the winter and the results are now being put into bulletin form.

During the year, with the resignation of the head of the rural engineering work of the station, the work of this department was connected with the agronomy department. The seepage and drainage studies have been continued by this division of the agronomy department.

Animal Industry: The animal industry department has two main lines of work, viz., experiments in beef production and experiments in pork production. During the year work with dairy cows has been taken over and also the dairy manufacture work.

The principal work in beef production during the year has been the continuation of the feeding record of fifteen beef type females carried through their second year. From these animals we plan to raise calves and carry them through till ready for the market. In this way we hope to get accurate data on the cost of raising and feeding beefing stock on the cultivated farm.

A bulletin has been prepared on the steer feeding work for the years 1906 to 1908.

In the experiments on pork production a large number of tests have been made, about twenty altogether, covering a wide range of questions. A large amount of data has been accumulated, but the work has to be repeated several times before conclusions can be drawn.

Substantial progress has been made in the wool investigations of the department, though many years of work are needed to get definite results on the main points of the investigations. The veterinary department is co-operating on this project in the histological studies of the wool fibre.

Chemical Department: The weight of the work of the chemical department during the past year was given to the alkali-cement investigation. This work was inaugurated by the engineering department and the physical phases of the problem were worked out by that department. The chemical studies of the problem had been carried by the chemical department and on the resignation of the station rural engineer all the work was taken over by the chemist.

Very substantial progress has been made during the year with this problem and it is believed that a chemical explanation of the destruction of the cement, when acted on by alkali, has been found. The result of this work will be published during next year.

In the incubator studies a large number of facts have been gathered during the year, giving much accurate data as to the condition surrounding the egg during natural and artificial incubation. An electric incubator or electrobator, was used during the year and proved a valuable aid to the work because of the very complete control of the temperature.

During the year the department made a large number of analyses for other departments, but particularly for the agronomy department, for which 1800 soil samples were analyzed for nitrates.

Horticulture Department: The work of the horticulture department was interfered with during the year owing to the fact that the head of the department resigned at the beginning of the crop season and a new man had to take hold on July 1st. The work as outlined at the beginning of the year was continued and data for another year have been added to our observations on tree fruits, small fruits and on vegetables.

At the horticultural substation in Ravalli county, no improvements were undertaken. The work of the year consisted in taking care of the trees and carrying out the tests on various methods of cultivating them.

Veterinary Department: The new department of veterinary

was engaged to take charge of this work. The old dairy building was fixed over for this department and the time and funds of the department have been given to getting the equipment in place for work and getting acquainted with the problems calling for attention in the state.

Poultry Department: The poultry work under the direction of Mr. W. F. Schoppe has made good progress during the year. The stock is in the best condition it has been for some years. Accurate results have been kept of the feed used and of the egg production from the various hens and a foundation is being laid for valuable work along practical lines. At the present stage of our work, we are putting particular stress on the development of an economic flock and studying the methods of management that make for the largest profit from Poultry keeping in Montana.

MAILING LIST.

The station mailing list increased during the year by about 1250 names and now totals 7247. Of this number, 3966 are citizens of Montana, about 100 names are from foreign countries and about 970 names are citizens of other states. The exchange list with other experiment stations in the United States numbers 2200. In addition to the above there were sent out from the office about 5000 miscellaneous bulletins which were called for by letter or otherwise. A bulletin edition of 9000 was published to meet these various demands.

PUBLICATIONS OF THE YEAR.

During the past year the station has adopted the plan of issuing two kinds of publications—bulletins and circulars. In the bulletins we will record the results of experiments. These publications may, from an agricultural point of view, be somewhat fragmentary, as they deal with but a small section of agricultural practice. In the circulars we will attempt to give practical information on some pressing need in the agricultural work of the state. They will be in the nature of extension bulletins and when funds warrant the establishment of such a department, they should be issued by that department.

During the year three bulletins and five circulars have been issued besides the Annual Report, covering altogether 136 pages. This has been one of our lightest years for publications. Owing to the pressure of work, much material on hand has been delayed in preparation so that at present there is quite an accumulation of data that we hope to get ready for publication during the coming season.

Bulletin No. 77. **Fruit Tree Planting in Montana** was prepared by Prof. R. W. Fisher before he severed his connection with the Station. It embodies the results of his studies and observations at the station and over the state for several years past. 36 pages.

Bulletin No. 78. **Steer Feeding Experiments** by Prof. R. W. Clark. The work recorded in this bulletin was started by F. B. Linfield, now director, and continued by Prof. Clark. It gives the results of feeding a carload of steers on different quantities for the different seasons. 12 pages.

Bulletin No. 79. **Seventh Annual Report of the State Entomologist.** 10 pages.

The **Sixteenth Annual Report** of the Experiment Station is the Director's report of the work and progress of the station during the past twelve months, 26 pages.

Circular No. 1. **Home Cheesemaking**, by Prof. W. J. Elliott, gives some practical information on cheese making on the farm. 8 pages.

Circular No. 2. **The Pear and Apple Blight in Montana**, by Prof. Deane B. Swingle, discusses the methods of identification and treatment of the pear and apple blight. 10 pages.

Circular No. 3. **Dry Farming Practice in Montana**, by Prof. A. Atkinson and Prof. F. S. Cooley, aims to give practical advice on methods of soil management and of cropping for the dry bench lands of the state, putting in brief, plain language the results of our experiments and observations in cropping such lands. 24 pages.

Circular No. 4. **The Army Cutworm**, by Prof. R. A. Cooley, was in answer to a demand for information about the army cut worm, which is this year again found in large numbers in several parts of the state. 10 pages.

LIST OF LITERATURE PUBLICATIONS AVAILABLE FOR DISTRIBUTION.

1. Organization—Announcements.
2. Smuts of Wheat, Oats and Barley.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
35. Report of Feeding Tests.
36. Forage Conditions in Montana.
40. Root Crops in Montana.
42. The Codling Moth.
- Ninth Annual Report.
44. Apple Growing in Montana.
45. The Loco and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
51. First Annual Report of the State Entomologist
52. Sugar Beets.
53. Creameries and Cheese Factories.
67. Practical Beekeeping.
69. The Effect of Alkali on Portland Cement.
70. The Douglas Fir Cone Moth.
71. The Fifth Annual Report of the State Entomologist.
75. The Sixth Annual Report of the State Entomologist.
76. Seepage and Drainage.
- The Fifteenth Annual Report.
77. Fruit Tree Planting in Montana.
78. Steer Feeding Experiments.
79. The Seventh Annual Report of the State Entomologist.
- Circular 1. Home Cheesemaking.
- Circular 2. The Pear and Apple Blight in Montana.
- Circular 3. Dry Farming Practice in Montana.
- Circular 4. The Army Cutworm.

METEOROLOGICAL REPORT.

WEATHER RECORD.
SUMMARY BY MONTHS FOR THE YEAR 1909.

Months	Maximum Temperature	Minimum Temperature	Monthly Mean Temperature	Precipitation	Number of Clear Days	Number of Partly cloudy Days	Number of Cloudy days	No. of days with .01 inch or more of Precipitation	Prevailing Wind Direction
January	51	-28	17.5	.72	3	22	6	6	S. E.
February	52	- 8	24.8	.35	2	14	12	4	S. E.
March	55	-11	30.9	1.42	11	15	5	12	S. E.
April	60	11	33.15	1.82	4	17	9	10	S. E.
May	74	24	45.6	4.15	6	22	3	13	S. W.
June	88	35	57.78	1.04	12	14	4	8	S. E.
July	93	39	63.25	1.98	15	13	2	7	S. E.
August	90	36	63.8	1.29	22	7	2	8	S. E.
September	80	30	53.85	5.54	8	18	4	13	S. E.
October	66	22	44.65	.77	7	20	4	4	S. E.
November	66	0	34.16	2.86	3	11	16	11	S. E.
December	45	-23	12.43	.90	3	16	12	8	S. E.

Summary for the Year 1909.

Highest temperature.....	93 degrees, July 1st.
Lowest temperature.....	— 28 degrees, Jan. 10th.
Greatest range.....	121 degrees
Highest monthly mean.....	63.8 degrees, August
Lowest monthly mean.....	12.4 degrees, Dec.
Highest daily mean.....	78 degrees, July 1st.
Lowest daily mean.....	— 18 degrees, Jan. 8th
Mean temperature for the year.....	40.16 degrees
Greatest total precipitation for one month....	5.54 inches, Sept.
Least total precipitation for one month.....	.35 inch, February
Total rainfall.....	22.34 inches
First killing frost.....	Sept. 11th
Last killing frost.....	May 18th
Number of clear days in year.....	96
Number of partly clear days in year.....	189
Number of cloudy days in year.....	80
Days with .01 inch or more of precipitation.....	104

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

F. B. LINFIELD, Director.

Seventeenth Annual Report

FOR THE FISCAL YEAR ENDING JUNE 30, 1910

BOZEMAN, MONTANA

FEBRUARY, 1911

MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

BOZEMAN, MONTANA

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STATION STAFF

F. B. LINFIELD, B. S. A., *Director*.
R. A. COOLEY, B. Sc., *Entomologist*.
ALFRED ATKINSON, B. S. A., *Agronomist*.
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J. B. NELSON, *Superintendent Dry Farm Work*.
REUBEN M. PINCKNEY, B. S., A. M., *Assistant Chemist*.
L. F. GIESEKER, B. S., *Assistant Agronomist*.
WM. F. SCHOPPE, B. S., *Assistant Poultryman*.
H. E. MORRIS, B. S., *Assistant Botanist*.
J. R. PARKER, B. A., *Assistant Entomologist*.
LYMAN G. SCHERMERHORN, B. S., *Assist. Horticulturist*.
R. F. MILLER, B. S. A., *Assistant Animal Industry*.
H. B. BONEBRIGHT, B. S. A., *Asst. Agricultural Engineer*.

NOTICE—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all the publications are desired as issued or only those specified. Give name and address plainly.

All communications to the Experiment Station should be addressed to
THE MONTANA EXPERIMENT STATION.

Bozeman, Montana.

LETTER OF TRANSMITTAL

Bozeman, Montana, January 31, 1911.

To His Excellency, Edwin L. Norris,
Governor of Montana.

Dear Sir:

In accordance with the Congressional Acts of March 2, 1887, and March 16, 1906, I have the honor to transmit herewith the Seventeenth Annual Report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1910; the results of investigations of the several departments are reported to the end of the state year, November 30, 1910.

Very respectfully,

F. B. LINFIELD, Director.

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REPORT OF TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1909-1910:

Dr.

	Hatch Fund	Adams Fund
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1910, under Acts of Congress approved March 2, 1887, (Hatch Fund), and March 16, 1906, (Adams Fund).	\$15,000.00	\$13,000.00

Cr.

By salaries	\$8,063.35	\$8,185.66
Labor..... ..	2,575.50	2,291.44
Publications..... ..	369.48	.....
Postage and stationery	756.38	16.93
Freight and express..... ..	196.71	79.73
Heat, light, water and power.....	534.48	.....
Chemical supplies	152.52	236.75
Seeds, plants and sundry supplies	526.73	337.87
Fertilizers .....	.....	.....
Feeding stuffs	415.10	497.49
Library	322.43	32.80
Tools, implements and machinery	201.65	91.25
Furniture and fixtures	215.84	49.65
Scientific apparatus	246.15	724.25
Live stock	129.75	.....
Traveling expenses	165.10	455.18
Contingent expenses	15.00	.....
Buildings and land,.....	133.85	.....
	<hr/>	<hr/>
Total	\$15,000.00	\$13,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the

State of Montana, for the fiscal year ending June 30, 1910; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$15,000.00 under the act of Congress of March 2, 1887, and \$13,000.00 under act of Congress of March 16, 1906, and the corresponding disbursements \$15,000.00 and \$13,000.00, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts.

Respectfully,

Signed:

J. H. BAKER.

WALTER S. HARTMAN.

Auditors.

Attest: G. R. CALLAWAY, Custodian.

EXPERIMENT STATION MISCELLANEOUS FUND

Dr.		State	Individ- uals	Farm Products	Total
To receipts from other sources than the United States for the year ended					
June 30, 1910		\$32,990.48	\$7,011.26	\$6,384.34	\$46,386.08
Cr.					
By salaries		\$4,199.16	\$232.00	\$1,380.00	\$5,811.16
Labor		8,943.70	4,334.82	3,321.45	16,599.97
Publications		100.00	20.00	.....	120.00
Postage and stationery		74.15	.....	69.55	143.70
Freight and express		172.02	288.99	74.78	535.79
Heat, light, water and power.....		763.04	.....	144.07	907.11
Chemical supplies		37.10	.....	.....	37.10
Seeds, plants and sundry supplies.		1,709.07	74.32	750.63	2,534.02
Fertilizers .....		.....	.....	.....	.....
Feeding stuffs		199.58	.....	193.30	392.88
Library .....		.....	.....	.....	.....
Tools, implements and machinery.		1,502.85	442.54	198.40	2,143.79
Furniture and fixtures		128.76	.....	57.60	186.36
Scientific apparatus		90.00	.....	.....	90.00
Live stock		1,635.18	.....	.....	1,635.18
Traveling expenses		894.12	1,121.84	.....	2,015.96
Contingent expenses		52.00	.....	2.50	54.50
Buildings and land		12,489.65	496.75	192.06	13,178.46
Total		\$32,990.48	\$7,011.26	\$6,384.34	\$46,386.08

REPORT OF THE DIRECTOR.

INTRODUCTION

The Adams Act passed by the United States Congress five years ago provided for the doubling of the appropriation to the agricultural experiment stations of the various States. We received the past year from this fund \$13,000.00, making a total of \$28,000.00 per year from the Federal Government. This year the total will be \$30,000.00, the full amount available under the Government Acts. Nevertheless, with the increased appropriations have come restrictions as to the use of these funds. The latest additions to our Federal grant can only be used in carrying on original investigations. They are not available for expenses of administration, maintenance of plant, nor for publications. None of the Federal funds can be used for the support or maintenance of substations, nor for many of the preliminary experiments that are called for in a new country. This necessitates large appropriations from the State if we are to make proper use of the Federal grants.

The increase in funds and the higher demands of the work have called for an increase in the number and an improvement in the training of the station workers and also for some reorganization of the work.

As our country is new agriculturally and is developing rapidly, it has seemed wise to emphasize in our work the productive side of agriculture and to study especially for improvement in our plants and animals and improved methods of growing and handling them. We have, therefore, enlarged greatly our work in agronomy, in animal industry, and in horticulture, while the chemistry department, which contributes to all of these, has also been strengthened.

We have not neglected, however, work on the protective side of agriculture, viz., the study of plant diseases, of insect pests, and of the evils arising from the excessive or wrong use of irrigation water.

Because of the need for a better quality of work and for greater concentration by our workers, most of the heads of departments now give three-fourths of their time to the station work while their assistants give their time either wholly to the station or wholly to the college. Our experience seems to justify the conclusion that this plan is conducive to the greatest economy and efficiency in the work of both the college and the experiment station.

IMPROVEMENTS

During the past year the appropriation for farm buildings made by the legislature of 1909 became available. Early in the season an addition to the poultry plant was built. This is 14 by 30 feet, with basement and one story above. The first floor provides an office and a class room, a sleeping room for an attendant, and bins for feed storage. The basement, which is of cement with cement floor, is used as an incubator cellar. The whole building is heated by the hot water system. This addition has very much improved the facilities for the poultry work. The cost was about \$1000.00.

Another building constructed was a sheep barn. This is 40 by 50 feet with two wings, one 20 by 88 feet and the other 20 by 60 feet. The main part of the building has under it a cellar 25 by 25 feet for the storage of roots, etc. One side of the first floor is used for sheep pens while the remainder is divided into work and storage rooms. Above this floor is a loft large enough for the storage of 50 tons of hay. The building is provided with a platform scale of 2000 pounds capacity and is equipped with running water and electric lights. A steer feeding barn was also erected, which is 50 by 50 feet with two wings, each 25 by 25 feet. This provides space for four feeding pens 21 by 25 feet. The rest of the first floor is used for feed rooms and grain storage. The floor above has storage room for about 75 tons of hay. A platform scale of four tons capacity is provided in this building. The sheep and steer feeding barns cost about \$8500.00.

The remainder of the \$10,000.00 appropriation made by the State, supplemented by some of the income from the farm, was spent in moving the implement shed about 60 feet to the north and away from the horse barn, and in the erection of a wing about 20 by 60 feet on one end of this shed. Half of this wing is

STEER FEEDING BARN. REAR VIEW

used for box stalls for horses and the other half for machinery. About \$800.00 was spent in these improvements.

On the Fort Ellis farm, which was turned over to the Experiment Station in the spring of 1909, were a large number of old buildings with worn-out shingles and rotten foundations. None of them were suitable for housing either the workmen or the live stock. The policy followed was to tear down some of the old buildings and use the material thus obtained in repairing others. One building has been remodeled,—a stone foundation put under it, a new floor laid, partitions put in, and the roof shingled. This now makes a very comfortable farm house. Another building has been made over into a horse stable suitable for ten to twelve horses, with storage above for several tons of hay. A long building that was erected as a mess house has also been fitted up for farm use. Half of it is used as a live stock shed and the other half for storage of grain and hay. These various improvements, together with some fencing that was needed, cost about \$2,000.00. There is yet required a shed for the storage of the various farm implements and wagons. This we hope to provide during the next season from the income of the farm.

At the dry farm substation in the Judith Basin, a farm cottage, a granary, and an implement shed were constructed. These cost about \$4,000.00. About \$1,000.00 was expended for horses, farm equipment, and a well.

At the horticultural substation in the Bitter Root Valley a farm cottage was erected at a cost of \$1,800.00 and a small stable for about \$400.00. About \$1,000.00 was spent for a team of horses, farm machinery, and other equipment.

SUBSTATIONS

At the dry farm substation in the Judith Basin we had close to the average precipitation for the season, though the rainfall in June and July was only about half the normal. The crops of all kinds were very good, though hardly equal to those of the previous season, in which there was an excessive rainfall. From the nature of the work carried on at this station, definite conclusions cannot be drawn from the studies being made for several years. As soon as any facts of value are available the results will be published.

The farmers of the neighborhood are very much interested in the work of this station. On July 29, 1910, the residents of the Basin were invited to a picnic at the station and fully 2,500 people were on the grounds. They drove in from thirty to forty miles, and the local trains from Great Falls and Billings brought large numbers, as the Great Northern Railway gave a special rate and ran the trains so as to permit the people to spend several hours at the farm. Many public men, including Governor Edwin L. Norris, were present and addressed the assembly. Because of the great interest shown in this gathering it is planned to make it an annual affair.

At the horticultural substation in the Bitter Root Valley little more could be done than to cultivate the ground and to prune the trees so as to encourage rapid and proper growth. The trees have done very well indeed during the season.

During the past year thirteen demonstration dry farms have been operated. New farms were started last year at Billings, Clyde Park, Helena and Harlowton. At several of these demonstration farms special meetings with farmers were held and the work of the farm fully explained.

On the average for the whole State, last year was the driest season experienced since the dry farm studies were started. In many places there was practically no rain during June, which is usually the wettest month of the year. Moreover, the month was very hot. Under the circumstances the crops of the season were very good indeed. At every place where the land was properly prepared the year before, paying crops were obtained.

COOPERATIVE EXPERIMENTS

As in years past the Montana Experiment Station has been carrying on work in cooperation with the United States Department of Agriculture, and with the Northern Pacific and the Chicago, Milwaukee and Puget Sound railways.

At the dry farm substation in the Judith Basin we are cooperating with the Offices of Dry Land Agriculture and of Grain Investigation of the Bureau of Plant Industry. We are also cooperating with the Bureau in work being started on the Huntley Project.

This cooperation has been of great help to the State as it has permitted large extension of our work.

On the college farm at Bozeman studies on the evaporation of water from irrigated land and its control have been carried on in cooperation with the Irrigation Division of the Office of Experiment Stations.

In the Bitter Root Valley our entomologist has been cooperating with the Bureau of Entomology in studies on the life history and control of the wood tick, which is concerned in the dissemination of the Rocky Mountain spotted fever.

During the past year the Northern Pacific railway contributed \$7,500.00 to our work on the demonstration dry farms. This was used to support work at Adams in Dawson County, at Terry (two farms) in Custer County, at Forsyth in Rosebud County, at Billings in Yellowstone County, at Clyde Park in Park County, and at Helena in Lewis and Clark County,—seven stations in all. This is the sixth year that the Northern Pacific railway has contributed to this work, and it has donated altogether \$23,000.00. When we consider that it was due to this company that we were able to start these dry farm studies six years ago, we realize that the Experiment Station, and also the State, have much reason for thankfulness to the Northern Pacific railway, and especially to Mr. Thomas Cooper, land commissioner, upon whose initiative the work was undertaken.

Two years ago the Chicago, Milwaukee and Puget Sound railway joined with the Experiment Station to carry on some demonstration farms along their line in Montana. Farms were started at Baker in Custer County, and at Roundup in Fergus County. During the past year this railway increased its appropriation to \$2,500.00 and a new farm was started at Harlowton.

All the railroads of the State, viz., the Northern Pacific, the Chicago, Milwaukee and Puget Sound, the Great Northern, and the Oregon Short Line, furnished free transportation to the Experiment Station staff engaged in the experimental and extension work over the State. This has been a very great help in extending our work. However, a decision of the State supreme court during the past fall declares the giving of passes for any purpose illegal, so that this accommodation can no longer be granted.

THE STATION STAFF

There have been no important changes in the station staff during the past year. Several new assistants have been engaged and a few readjustments made of the time given to the station work by some of the staff.

Last June Mr. Daniels Scoates, a graduate of Iowa Agricultural College, was engaged as assistant agricultural engineer. Inside of three months, however, an offer of greatly increased pay from another institution led him to resign his position with us. Mr. H. B. Bonebright, a graduate of the Iowa Agricultural College and for three years past assistant in agricultural engineering at the Colorado Agricultural College, has been engaged to take charge of the work, beginning February 1, 1911.

At the beginning of the fiscal year, July 1st, Mr. J. R. Parker, a graduate of Massachusetts Agricultural College, was engaged as assistant entomologist to give his whole time to station work. At the same time Mr. L. G. Schermerhorn, a graduate of the same institution, was engaged as assistant horticulturist, giving one-half time to the Experiment Station. On September 1st Mr. R. F. Miller, a graduate of Texas Agricultural College, was engaged as an assistant in animal industry, to give all his time to station work. Mr. H. P. Griffin, who last year gave two-thirds time to the Experiment Station, was transferred wholly to college work. Prof. R. W. Clark, head of the animal industry department, since July 1st has given three-fourths of his time to Experiment Station work instead of one-half as heretofore. Mr. R. C. Jones, who was engaged as dairyman when Prof. W. J. Elliott left, was transferred wholly to college work.

AGRICULTURAL EXTENSION

FARMERS' INSTITUTES

The station staff continues to give considerable time to the farmers' institute work, though the demands have not been as great as in previous years. During the month of June nearly all the staff spent one to two weeks in giving instruction on a special "better farming" train that was run across the State by the Northern Pacific Railway company. This was our first experience with the

agricultural train. It proved a very attractive and valuable feature of the work.

During the year there has been a growing interest in the farmers' institute work, especially from the new settlers who are rapidly taking up the vacant government lands of the State.

During the spring of 1910 Mr. J. J. Hill, of the Great Northern railway, offered \$1000.00 for prizes in a corn growing contest among the boys and girls of the State. This aroused considerable interest and in spite of an unpropitious season some excellent samples of corn were grown, Yellowstone County carrying off the prize for the best ten ears.

The practical talks at the several high schools of the State have been continued during the year and a lively interest in the lectures has been shown.

CORRESPONDENCE

The Experiment Station staff, in addition to its regular duties, is carrying on a large correspondence school. During the past six years the office force of stenographers has increased from one to five, and, if the demands for information continue to grow, additional help will have to be secured during the coming year.

For the year ending November 30, 1910, 7500 letters were sent out. This correspondence was distributed among the departments as follows: Agronomy, 2100 letters and 2000 circulars; animal industry, 1000 letters; biology, 1200 letters; chemistry, 200 letters; horticulture, 560 letters; poultry, 450 letters; director's office, 1000 letters; farmers' institutes, about 1000 letters and several thousand circulars.

THE WORK OF THE YEAR

Definite results from agricultural experiments generally take several years to work out. As a rule, therefore, it is not possible to report more than progress on most of the experiments at the end of the year.

At the present time there are in progress over forty different experiments on various phases of agriculture and related sciences. Half of the money received from the Federal government, known as the Adams Fund, is concentrated on eleven of these investigations.

Biology Department: The demands on the biology department are growing much faster than our ability to take care of them. No new work was taken up by the department during the year, but substantial progress has been made on the projects in hand.

Studies were continued on the control of the oyster shell scale. Some additional facts have been gathered about the life history of this pest and during the year work has been started on the introduction of parasitic mites to aid in its control.

The work on sugar beet insects has resolved itself into a study of certain insects, among which the sugar beet louse and the grasshopper are prominent. Good progress has been made but much work yet remains to be done.

A most important part of the work of the department was the study of the wood tick, carried on principally in the Bitter Root Valley. This work was supported by the State appropriation for the state entomologist and by funds contributed by the Bureau of Entomology, U. S. Department of Agriculture. Important progress was made in this study during the year and a publication is planned, reporting the results of the work to date.

In following up the insect survey of the State, observations have been made on a large number of insects.

The leading problem carried on by the botanist and bacteriologist has been a study of the effect of arsenical compounds on vegetation. Experiments have been started on orchard trees, on garden crops, and in the greenhouses. During the summer a trip was made to Colorado and Utah to get acquainted with similar studies being carried on at these stations. The Montana Station is under obligation to the men of these stations for their cordial help and assistance in learning the conditions of the problem as it exists in those states.

An important conclusion reached is that serious injury to apple trees may, under certain conditions, result from application of the so-called "insoluble" arsenical insecticides. Studies are being continued on the extent of this injury, the conditions under which injury is done, and the methods of protection that may be resorted to.

Considerable advancement has been made in the study of the Montana apple canker, the collar rot of apples, and the black heart of apples. A new disease designated as the "brown bark spot" has

been observed doing considerable injury in a few districts of the State.

With the agricultural development of the State and the increase in the number of fruit trees planted, especially in the newly settled sections, comes an increase in the diseases of fruit trees. Observations have been made during the year on the pear and apple blight, the apple scab, some plum diseases and the strawberry leaf spot.

The division has also been called upon to make a large number of tests and examinations in order to facilitate diagnosis of diseases, to determine the sanitary condition of ice and water, and to identify many plants, weeds, etc. This is routine work outside any particular problem. It takes considerable time but is required by the people of the State.

Agronomy Department: The agronomy studies are of very great importance in a new and developing country. The beginning of all agricultural practice is the plant crop from the land. What methods of soil management to follow and what crops to sow to get the largest and most profitable returns from the land, are leading questions.

For the past five years, because of the very large number of people coming to the State and settling on the bench lands, the dry farm studies have been made a prominent part of the work of the agronomy department. Some very substantial progress has been made. The studies of the past six years on the temporary dry farm stations have been compiled and published as Bulletin No. 83. Some definite conclusions as to dry farm practice in the drier sections of the State are given in this bulletin. These experiments were of necessity limited in their scope and present but a beginning in the study of the problems of dry land agriculture.

At the dry farm substation in the Judith Basin, where extensive and comprehensive studies on soil and crop management and dry farm crops are being carried on, the season's work was most successful.

On the field experimental grounds on the college farm, a large number of cropping tests are being conducted. The past season completes five years of study with some of these grains and a bulletin, No. 84, has been prepared, giving the results of variety studies made

with wheat, oats, and barley; also some conclusions on the amount of seed to use and the most favorable date to sow the seed.

The seepage studies were interrupted by the resignation of Mr. Scoates but will be resumed as soon as his successor can take up the work.

The moisture and nitrate studies were continued during the season at the Forsyth substation. Some very interesting and valuable facts have been worked out, and these are being prepared for publication. As our lease on the Forsyth farm has expired the work will be transferred to the Fort Ellis farm near Bozeman.

Animal Industry Department: The work with both beef and dairy cattle has been interfered with considerably during the year. Exact records are being kept of the cost and income from both beef and dairy animals.

Slow but definite progress is being made in the studies with wool.

With hogs, an extensive series of experiments is being conducted that have a practical bearing on hog feeding in Montana.

Chemistry Department: During the year the chemistry department has completed the work and prepared for publication the results of the studies on the effect of alkali on Portland cement. The full report of the work and the results secured is given in Bulletin No. 81. A popular edition of this bulletin is issued as a circular entitled "Action of Alkali on Hydraulic Cements." The department has yet to study various waterproofers and their action and effect in protecting cement structures.

Work on egg incubation was continued during the season and new facts are being added to our knowledge of conditions and reactions accompanying incubation, both in the incubator and under the hen.

A new project was taken up at the beginning of the summer season. It was a broadening of the work on nitrates, which was started a few years ago by the agronomy department. Only a start was made in this work during the year.

In addition to the above the department has made several routine analyses for other departments. For the agronomy department seven hundred to eight hundred samples of soil have been analyzed

for nitrate, and a number of miscellaneous analyses have been made for the animal industry and biology departments. The meteorological observations for the year have been continued. The record for the year 1910 is included in this report.

Horticultural Department. The work of this department has been along lines laid out in previous years. On the college farm a large variety of vegetables have been tested, and various methods of management applied. It is planned to publish the results of this work in the near future.

Observations have been continued on small fruits, the tree fruits, and the ornamental trees and shrubs. Several young and new varieties have been planted and studied.

During the summer a bulletin prepared by Prof. R. W. Fisher, our former horticulturist, "Ornamental Trees and Shrubs for Montana," was published.

At the horticultural substation nothing further was attempted than to keep the fruit trees and small fruits growing, and to take notes on the effect of different methods of cultivation on their growth and thriftiness. The trees made excellent growth during the year.

Veterinary Department: But one-third of the time of the veterinary department was given to experiment station work the past season. Work on the study of wool has been done in cooperation with the animal industry department, and some studies have been made on treatments for contagious abortion among cattle. Considerable equipment has been added during the year so that the laboratories are now in excellent shape for the work of the department. Much of the time of the head of the department has been given to the care of the live stock on the farm.

Poultry Division: As during the previous season the poultry work has been carried on as a demonstration, making exact studies of the cost of production, the returns from different pens, and from different breeds. Trap nests are being used in all the pens and eggs from the best layers only taken for hatching. Several types of houses are being used and their adaptability to climatic conditions in Montana is being studied.

THE MAILING LIST

The mailing list of the Experiment Station continues to increase, about one thousand names having been added during the year, most of them from the State.

The total number of names on this list is now about 8,400. Of these about 4,600 are from Montana, 1,200 from other states, 113 from foreign countries, and 2,500 from other colleges and experiment stations in the United States.

In addition to the bulletins sent out to those on the mailing list, about 5,000 were sent out in answer to special requests.

PUBLICATIONS OF THE YEAR

Five bulletins, the seventeenth annual report, and four circulars make up the publications of the year.

The bulletins record the results of our investigations as reported to date, and the circulars present in popular form some facts on agricultural practice adapted to Montana conditions—the results of our experiences, studies, and observations in this State. The circulars are for distribution only in the State. The bulletins cover 261 pages and the circulars 50 pages.

Bulletin No. 80, "Ornamental Trees and Shrubs for Montana," was written by Prof. R. W. Fisher before he severed his connection with the station. It records the results of observations and studies made on the grounds of the Experiment Station and over the State on shade trees and shrubs. Forty-six pages, edition 9,000.

Bulletin No. 81, "The Destruction of Hydraulic Cements by the Action of Alkali Salts," by Prof. Edmund Burke, assisted by R. M. Pinckney, gives the results of the chemical studies on the action of alkali on Portland cement. It is a technical bulletin and not for general distribution. A popular edition has been prepared and issued as Circular 8. Eighty-six pages, 8 plates, edition 5,000.

Bulletin No. 82, "The Eighth Annual Report of the State Entomologist," is a statement of the work and needs along entomological lines in this State. It is not for general distribution but will be sent to any person upon request. Sixteen pages, edition 5,000.

Bulletin No. 83, "Dry Farming Investigations in Montana," by Prof. A. Atkinson, covers nearly the same ground as Bulletin No.

74, but adds the results gained from two more years of study, thus enabling more valuable conclusions to be drawn. Fifty-four pages, 21 plates, edition 15,000.

Bulletin No. 84, "Grain Investigations with Wheat, Oats and Barley," by Prof. A. Atkinson, records the results of five years' study of many varieties of grain and methods of planting them, the work having been done on the station field experimental grounds. Twenty-four pages, 4 plates, edition 12,000.

The Seventeenth Annual Report of the Experiment Station is the Director's report of the work and the progress of the Experiment Station during the past year. Thirty-one pages, 2 plates, edition 12,000.

The circulars have been prepared to meet a popular demand for information on farm practice, applicable to Montana conditions. Large editions are being published, and the list of titles will be added to as rapidly as time and means will permit.

Circular 5, "Alfalfa Management in Montana," by Prof. A. Atkinson, is a brief statement in regard to the seeding and management of alfalfa. Seven pages.

Circular 6, "Flax Growing in Montana," by Prof. A. Atkinson and Prof. D. B. Swingle, gives some essential facts as to flax growing and the crop management, and the treatment of seed necessary to avoid the flax wilt disease. Eight pages.

Circular 7, "Preliminary Report on the Analyses of Montana Waters," by Prof. W. M. Cobleigh and others, calls attention to the problems to be considered in determining the quality of the water supply, indicates the impurities that are sometimes found, and illustrates a cheap still for removing alkali from water. Seventeen pages.

Circular 8, "Action of Alkali on Hydraulic Cements," by Prof. Edmund Burke, presents some practical deductions from Bulletin No. 81. Fifteen pages.

DONATIONS AND LOANS

12 Lulla-By brooders, Park & Pollard Co., Boston, Mass.

1 Buckeye incubator, 150-egg capacity, Buckeye Incubator Co., Springfield, Ohio.

Feed hoppers, Poultry Dry Feed Hopper Co., Boston, Mass.

Spray nozzles and attachments, Deming Co., Salem, Ohio.

Garden seed, W. Atlee Burpee & Co., Philadelphia, Pa.

Orchard heaters, Ideal Orchard Heater Co., Grand Junction, Colo.

National Orchard Heater Co., Grand Junction, Colo.

Hamilton Orchard Heater Co., Grand Junction, Colo.

Round Crest Fruit Co., Canyon City, Colo.

Richardson Frost Prevention Co., Kansas City, Mo.

Colorado Commercial & Fruit Assn., Grand Junction, Colo.

Apple box lid press, H. Pratt & Sons, Como, Mont.

PUBLICATIONS OF THE MONTANA EXPERIMENT STATION AVAILABLE

FOR DISTRIBUTION

BULLETINS

No.

1. Organization—Announcements.
2. Smuts of Wheat, Oats and Barley.
13. Drinking Water.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
35. Report of Feeding Tests.
36. Forage Conditions in Montana.
37. Pork Production in Montana.
38. Food Adulteration.
40. Root Crops in Montana.
41. Sugar Beets.
42. The Codling Moth.
Ninth Annual Report.
44. Apple Growing in Montana.
45. Loco and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
49. Contagious Abortion in Montana.
51. First Annual Report of State Entomologist.
Tenth Annual Report.
52. Sugar Beets.
53. Creameries and Cheese Factories.
62. Third Annual Report of State Entomologist.
67. Practical Beekeeping.
68. Canadian Field Peas.
69. The Effect of Alkali on Portland Cement.
70. The Douglas Fir Cone Moth.
71. Fifth Annual Report of State Entomologist.
Fourteenth Annual Report.
73. Pig Feeding Experiments.
75. Sixth Annual Report of State Entomologist.
76. Seepage and Drainage.
Fifteenth Annual Report.

77. Fruit Tree Planting in Montana.
78. Steer Feeding Experiments.
Sixteenth Annual Report.
80. Ornamental Trees and Shrubs for Montana.
81. Destruction of Hydraulic Cements by the Action of Alkali Salts.
82. Eighth Annual Report of State Entomologist.
83. Dry Farming Investigations in Montana.
84. Grain Investigations with Wheat, Oats and Barley.
Seventeenth Annual Report.

CIRCULARS

No.

1. Home Cheesemaking.
2. The Pear and Apple Blight in Montana.
3. Dry Farming Practice in Montana.
4. The Army Cutworm.
5. Alfalfa Management in Montana.
6. Flax Growing in Montana.
7. Water Analyses in Montana.
8. Action of Alkali on Hydraulic Cements.

WEATHER RECORD

SUMMARY BY MONTHS FOR THE YEAR 1910

Edmund Burke, Meteorologist.

Months.	Highest temperature.	Lowest temperature.	Mean temperature.	Precipitation.	Clear days.	Partly cloudy days.	Cloudy days.	Days with 0.01 of an inch or more precipitation.	Direction of prevailing winds.
January ...	47	-21.5	18.1	0.82	5	18	8	7	SW.
February ..	48	-29	14.1	0.82	4	13	11	8	SE.
March	69	19	42.1	0.62	11	18	2	3	SW.
April	81	20	47.4	1.86	12	14	4	5	SW.
May	79	26	49.8	2.72	16	11	4	9	SW.
June	93	27	59.2	1.35	12	17	1	7	SE.
July	92	41	66.2	0.73	12	19	0	7	SE.
August	89	26	59.9	1.46	17	13	1	4	SE.
September .	81	27	50.8	3.51	9	13	8	9	SE.
October ...	82	17	46.5	2.74	12	16	3	6	SW.
November ..	61	4	33.3	1.70	3	12	15	7	SW.
December ..	45	-4	24.7	0.41	8	24	4	2	SE.
For the year			42.6	18.74	116	188	61	74	

Highest temperature 93, June 27th.
Lowest temperature -29, February 22nd.
Greatest range for the year 122.
Highest daily mean..... 79.5, July 17th.
Lowest daily mean.....-17, February 22nd.
Last killing frost June 3rd.
First killing frost August 24th.

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

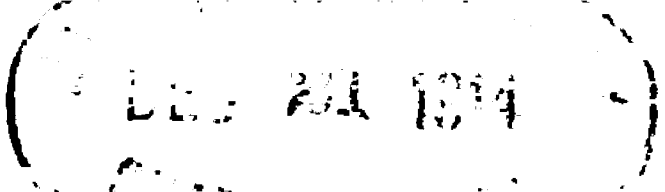
F. B. LINFIELD, Director.

Eighteenth Annual Report

FOR THE FISCAL YEAR ENDING JUNE 30, 1911

BOZEMAN, MONTANA
FEBRUARY 1912

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MONTANA AGRICULTURAL COLLEGE

EXPERIMENT STATION

BOZEMAN, MONTANA

STATE BOARD OF EDUCATION

EDWIN L. NORRIS, Governor	}	<i>Ex-Officio</i>	Helena
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GEO. R. CALLAWAY, Secretary.	Bozeman

STATION STAFF

F. B. LINFIELD, B. S. A., Director.
R. A. COOLEY, B. Sc., Entomologist.
ALFRED ATKINSON, B. S. A., Agronomist.
ROBERT W. CLARK, B. Agr., Animal Industry.
EDMUND BURKE, B. S., Chemist.
DEANE B. SWINGLE, M. S., Botanist and Bacteriologist.
O. B. WHIPPLE, B. S., Horticulturist.
W. J. TAYLOR, D. V. M., Veterinarian.
J. B. NELSON, Superintendent Dry Farm Work.
REUBEN M. PINCKNEY, B. S., A. M., Assistant Chemist.
L. F. GIESEKER, B. S., Assistant Agronomist.
WM. F. SCHOPPE, B. S., Assistant Poultryman. *
H. E. MORRIS, B. S., Assistant Botanist and Bacteriologist.
J. R. PARKER, B. A., Assistant Entomologist.
LYMAN G. SCHERMERHORN, B. S., Assist. Horticulturist.
R. F. MILLER, B. S. A., Assistant Animal Industry.
H. B. BONEBRIGHT, B. S. A., Asst. Agricultural Engineer.
M. L. WILSON, B. S. A., Assistant Dry Farm Investigations.
A. J. CARROLL, Clerk.

* Absent on leave.

NOTICE—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all the publications are desired as issued or only those specified. Give name and address plainly. All communications to the Experiment Station should be addressed to
THE MONTANA EXPERIMENT STATION.
Bozeman, Montana.

LETTER OF TRANSMITTAL .

Bozeman, Montana, January 31, 1912.

To His Excellency, Edwin L. Norris,

Governor of Montana.

Dear Sir:

In accordance with the Congressional Acts of March 2, 1887, and March 16, 1906, I have the honor to transmit herewith the Eighteenth Annual Report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1911; the results of investigations of the several departments are reported to the end of the state year, November 30, 1911.

Very respectfully,

F. B. LINFIELD, Director.

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REPORT OF TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1910-1911.

Dr.

	Hatch Fund	Adams Fund
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1911, under Acts of Congress approved March 2, 1887, (Hatch Fund), and March 16, 1906, (Adams Fund).	\$15,000.00	\$15,000.00

Cr.

By Salaries	\$ 8,594.16	\$ 9,942.50
Labor	2,938.24	1,141.38
Publications	1,059.82	
Postage and stationery	557.79	80.09
Freight and express	138.26	225.84
Heat, light, water and power	387.83	7.00
Chemical supplies	91.90	907.25
Seeds, plants and sundry supplies.....	402.11	197.02
Fertilizers		
Feeding stuffs	99.28	410.92
Library	203.60	120.64
Tools, implements and machinery	127.75	481.48
Furniture and fixtures	78.75	162.81
Scientific apparatus	37.46	46.44
Live stock	29.00	115.45
Traveling expenses	228.30	1,027.33
Contingent expenses	25.75	
Buildings and land		133.85
Total	\$15,000.00	\$15,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and ac-

counts of the Experiment Station of the Agricultural College of the State of Montana, for the fiscal year ending June 30, 1911; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$15,000.00 under the act of Congress of March 2, 1887, and \$15,000.00 under act of Congress of March 16, 1906, and the corresponding disbursements \$15,000.00 and \$15,000.00, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts.

Respectfully,

Signed:

J. H. BAKER.

J. F. BLAIR.

Auditors.

Attest: G. R. CALLAWAY, Custodian.

EXPERIMENT STATION MISCELLANEOUS FUND.

Dr.		Individ-	Farm	
	State	uals	products	Total
To receipts from other sources than the United States for the year ended June 30, 1911.....	\$44,353.99	\$9,432.66	\$6,858.19	\$60,644.84
Cr.				
By Salaries	\$ 5,255.00	\$ 675.00		\$ 5,930.00
Labor	11,427.11	4,202.02	3,097.79	18,726.92
Publications	375.10		316.36	691.46
Postage and stationery.....	94.36		459.44	553.80
Freight and express	109.43	289.80	31.55	430.78
Heat, light, water and power.....	963.27	4.50	99.53	1,067.30
Chemical supplies	301.53	667.16	231.61	1,200.30
Seeds, plants and sundry supplies	1,738.41	515.95	458.60	2,712.96
Fertilizers	50.00			50.00
Feeding stuffs	854.80	11.37	431.43	1,297.60
Library				
Tools, implements and machinery	2,138.87	423.90	310.00	2,872.77
Furniture and fixtures	194.18		26.10	220.28
Scientific apparatus	212.94			212.94
Live stock	1,634.17	350.00	125.00	2,109.17
Traveling expenses	1,462.52	2,255.45	67.78	3,785.75
Contingent expenses	209.45	29.81	809.70	1,048.96
Buildings and land	17,338.85	7.70	393.30	17,734.65
Total	\$44,353.99	\$9,432.66	\$6,858.19	\$60,644.84

Report of the Director

INTRODUCTION.

The State has continued to grow and develop along agricultural lines during the past year and the Experiment Station work has increased correspondingly. The State legislature at its last meeting recognized the increased demands upon the station by substantial increases in appropriations for its work. The maintenance fund of the station was increased by \$7,500.00 or to \$20,000.00 for 1911-12 and to \$22,500.00 for 1912-13. The support for the dry farm work was increased to \$16,000.00 for 1911-12 and \$20,000.00 for 1912-13. For improvements and buildings at the home station \$14,000.00 was given: \$10,000.00 of this for greenhouses for the use of the horticulture, agronomy, and biology departments, and \$4,000.00 for farm sheds and a silo.

Increased appropriations were also given for the work of the substations. For the dry farm substation in Fergus County \$3,000.00 per year was given, and \$4,500.00 for buildings and improvements. For the horticultural substation in Ravalli County \$2,000.00 per year was given for maintenance, and a total of \$2,500.00 for improvements. The total increase in appropriations over those of the year before was \$16,250.00 for 1911-12 and \$22,750.00 for 1912-13 for maintenance funds, and an increase of \$3,000.00 for improvements for the two years.

The Northern Pacific railway, which had given \$7,500.00 for the dry farm work, and the Chicago, Milwaukee and Puget Sound railway, which had given \$4,000.00 for the same work, decided that their support for the continuation of the dry farm stations was no longer necessary, and so decreased their appropriations—the Northern Pacific giving \$1,000.00 and the Chicago, Milwaukee and Puget Sound \$400.00 for the year. Practically, therefore, the net increase for maintenance for this year over the previous year was but \$6,250.00.

The station is endeavoring to develop the scientific character of its work, and finds a growing demand for experienced workers in pure science. The departments of agronomy, animal industry, horticulture, etc., are making increased demands upon the biologists and chemists of the station. In view of this fact an additional chemist was provided, and more of the time of the bacteriologist and botanist was given to the station work. The probabilities are that the demands in this direction will increase, as all of the departments recognize the great dependence of their work on accurate data.

However, while endeavoring to improve the scientific character of our work we are also trying to bring to the people of the State a large fund of accurate practical information on many agricultural problems. This we are furnishing through the series of circulars, nine of which were published during the year. Our plan is to add to the list as fast as material can be prepared. The cost of printing these circulars can only be paid from State funds as they are not directly the results of original investigations, but of the general study and observation of Montana farm conditions. The preparation and printing of these circulars could be taken over by the extension department of the college when its organization is completed.

IMPROVEMENTS.

During the summer and fall of 1911 the \$10,000.00 appropriated by the legislature for greenhouses was expended in the erection of a series of greenhouses for the horticulture and agronomy departments and a smaller house for the biology department. The large greenhouse has two main ridges, and a palm house which is located in the center of one of these ridges. The houses are located on the south end of the agricultural building. (See figure 1.) To protect the glass from the drip of this building an entry way 10 by 56 feet was constructed between the agricultural building and the greenhouses. This has a cement floor and a reenforced concrete roof, and is used as a soil and potting room. The greenhouse is divided into five distinct rooms, viz., for propagating, for vegetables, for roses, for carnations, and the palm house. The latter

is 39 feet square, with a clear open space of 16 feet to the lantern, and is made with steel frame. The semi-iron construction is used elsewhere, with iron sills and plates. The foundation, walls and the walks are of cement. All the wood is cypress. We have in this building a very substantial structure, and a very valuable addition to the equipment of the station. This greenhouse cost about \$8,500.00.

The biology greenhouse is one ridge 22 by 50 feet, and of wood construction with iron pipe posts. The foundation walls and

FIG. 1. HORTICULTURAL GREENHOUSES.

the walks are of cement. This building is located south of the biology building and adjoining the old biology greenhouse. To protect the glass from the drip of the biology building a shingled roof six feet wide was constructed over both greenhouses. This building cost about \$1,500.00. (See figure 2.)

From the general funds of the station, about one mile of fence was constructed on the west farm, being an outside fence on the north and east of the quarter section. The cost of this improvement was about \$350.

On the Fort Ellis farm a wagon and implement shed was constructed, 60 feet long and 25 feet wide, at a cost of about \$500.00. In addition considerable repairing was done to the fences.

In cooperation with the college a local exchange telephone has been installed, connecting the various buildings and offices on the

FIG 2. BIOLOGY GREENHOUSES.

grounds and also giving exchange service to the city of Bozeman and the Fort Ellis farm. The system has been a very great convenience in facilitating the work of the departments. The station invested about \$300.00 in this improvement.

From the appropriation of \$4,500.00 made for improvements at the Fergus County substation, a horse barn 30 by 40 feet and an implement shed 20 by 60 feet were erected. In addition verandas were built on the front and rear of both the farm house and the superintendent's cottage. All the buildings were repainted. This practically completes the buildings needed at this station for some years to come. (See figure 4.)

An appropriation of \$2,500.00 was made for improvements at the horticultural substation in the Bitter Root Valley. This provided a horse barn and implement shed, and also finished two other buildings that had been partly completed. This substation is now well equipped with buildings. (See figure 3.)

FIG. 3. BUILDINGS AT HORTICULTURAL SUBSTATION,
RAVALLI COUNTY.

SUBSTATIONS.

We have at the present time nineteen demonstration dry farms. These, with the two dry farm experiment stations, make twenty-one points in the State where we are studying local dry farm conditions. Our aim has been, so far as possible, to locate these dry farms in representative districts of the State without getting too far from the railroad. We believe that the farms at present in operation, with two or three others that have served their purpose and been discontinued, will in a few years give us a very complete understanding of the dry farm sections of the State. These dry farm studies are being carried on at or near the following towns: Baker, Wibaux, Circle, Terry, Huntley, Clyde Park, Twin Bridges, Dillon, Helena, Drummond, Ronan, Eureka, Great Falls, Conrad, Box Elder, Harlem, Glasgow, Froid, Moccasin, Harlowton, and Roundup.

The dry farm substation in Fergus County made good progress in its work during the year. The results of three seasons' observations are on hand but the character of the work is such that the observation must be continued for the next two years or longer before the results can be published. During the past year several hundred select lots of seed were grown in the breeding plots, and we hope in a few years through careful records and rigorous selection to have some improved varieties of dry farm grain to offer our farmers. The crop rotation tests are being continued and very satisfactory results were had during the past season.

FIG. 4. BUILDINGS AT DRY-FARMING SUBSTATION, FERGUS COUNTY.

The annual farmers' picnic at this substation is growing in interest. It is an event that draws together 2,500 to 3,000 people from all parts of the Judith Basin. The past summer this meeting was held on July 25th. The Great Northern railway gave an excursion rate from Great Falls and from Billings and changed the time of the local train for the day to accommodate the people who desired to visit and inspect the work of the station. The new buildings greatly improved the facilities for the accommodation of the people.

The horticultural substation in Ravalli County made satisfactory progress in the studies on hand. The young trees are healthy and made good growth, and the effects of different methods of cultivation and handling are becoming apparent. The coming season will see the completion of the planting contemplated at this place.

COOPERATIVE WORK

The work of the Experiment Station has been materially advanced by funds contributed by and cooperative arrangements made with the U. S. Government and others. The Bureau of Plant Industry of the U. S. Department of Agriculture, through its dry farm and grain investigation offices, is cooperating with us at the Fergus County substation and the Huntley substation. At the home station, Bozeman, the Irrigation Division of the Office of Experiment Stations, U. S. Department of Agriculture, is aiding us in moisture and irrigation studies.

During the year, owing to complaints of duplication, the U. S. Bureau of Entomology, which had been spending \$4,000.00 or over in studies on the spotted fever tick in the Bitter Root Valley, largely withdrew from the work at the end of last September. A very large amount of valuable data about the life history of this tick have been gathered, and we were in a fair way toward finding a satisfactory method of controlling it had it been possible to continue the work for another season or two. A complete and full life history of the insect can, we believe, be worked out only by an experienced entomologist. Some few observations will be continued, but the completion of the work must wait on a settlement of the difficulties complained of and the provision of the funds necessary.

THE STATION STAFF.

No important changes were made in the station staff during the past year. Two more assistants were added: Mr. M. L. Wilson, a graduate of the Iowa Agricultural College, as assistant in the dry land work; and Mr. D. C. Cochran of the Pennsylvania State College as assistant chemist. Two months after his engagement Mr. Cochran was persuaded to return to Pennsylvania by increased pay and improved opportunities for advancement. After

considerable search we found another man for the position.—Mr. G. E. Smith, a graduate of Toronto University, now assistant chemist at the Ontario Agriculture College. He starts work with us on April 15, 1912.

Mr. Wm. F. Schoppe, who has been in charge of the poultry for the past three years, was granted leave of absence to take post-graduate work at the University of Maine. He left about the middle of September.

AGRICULTURAL EXTENSION.

With the increased funds available for farmers' institute work it has been possible to engage experienced outside help, and thus fewer calls have been made on the members of the station staff, though from one to four weeks have been given to this work by nearly all of them.

The last legislature appropriated \$10,000.00 per year for the farmers' institutes, an increase of \$2,000.00 per year. This has permitted increasing the number of meetings and getting out into new territory. The attendance and interest continues to grow rapidly. In the latter part of March and the beginning of April, 1911, a special train was run over the Northern Pacific railway line in the State. The train consisted of ten cars, eight for agricultural exhibits and lectures, and two living cars. Some fourteen of the college teachers and experiment station staff accompanied the train over a period of two weeks. The interest in the demonstration work of the train was all that could be desired, as between 25,000 and 30,000 people visited it at the various stops made.

The lectures at the high schools of the State have been continued and a beginning made in an attempt to interest the county public teachers in agricultural instruction.

CORRESPONDENCE.

Nearly 12,000 letters were received by the various departments of the Experiment Station during the past year. About 4,000 of these were answered by sending a bulletin or circular which would give the information desired. The various departments sent out letters as follows: Director's office, 1,825; agronomy, 3,070; ani-

mal industry, 710; biology, 1,198; chemistry, 425; horticulture, 590; poultry, 507.

WORK OF THE YEAR.

Biology Department: This department has devoted most of its time to Adams projects. During the year much study was given to the sugar beet louse, which appears to be the worst insect pest of the beet in this State. Observations were made on other sugar beet insects, but conditions were not favorable for extended study.

Conclusive results have been obtained from the work with the oyster shell scale. Two publications dealing with these results will be prepared during the coming year.

The study of the wood tick in the Bitter Root Valley was continued during the most of the past year in cooperation with the U. S. Bureaus of Entomology and of Biological Survey. The generous support given by these bureaus enabled the department to get a large amount of information about the life history of this insect, and yet continual surprises are coming up. Plans were laid for a thorough and exhaustive study of the life history and methods of control of this tick—believed to be so closely related to the transmission of Rocky Mountain spotted fever. The plans involved, first, the possibility and the methods necessary for clearing the ticks from an isolated tract of about two sections of land. Second, longevity tests, as it has been found that the ticks live much longer between the feeding periods than was at one time suspected. Third, dipping tests with live stock to find the best dipping solution; how often to dip, how long each season and the number of seasons to continue the dipping, and various other problems growing out of this work.

Unfortunately, because of complaints of duplication of work from other state departments, the U. S. Bureau of Entomology withdrew from the work in September last, and the station is without sufficient funds to continue the work as planned at this time.

One bulletin on this work has been published during the year, and two others are planned for the coming season.

In addition to the above, miscellaneous observations have been made on other insects and remedies for the same. A more detailed

statement of this work is given in bulletin No. 88, the report of the State Entomologist.

The botanist and bacteriologist has given most of the year to two Adams problems, viz; the effect of arsenic on vegetation, and bark and wood diseases of the apple, while a beginning has been made on a soil-bacteriological problem in cooperation with the agronomy and chemistry departments. Substantial progress has been made in all the work in hand, but no conclusions are yet available for publication.

In addition to the above, the department has made preliminary investigations on several plant diseases—some of them new to the State.

Agronomy Department: The work of the agronomy department has grown much during the year, more especially the work over the State. For the past few years the dry farm studies have demanded most of the time of the department, owing to the great need of the many people settling on the bench lands of the State.

On the college farm, under irrigation, grain variety testing is being continued; also rotation tests, forage crop tests, and irrigation tests. In addition, duty of water studies are being carried on for the Irrigation Division of the U. S. Department of Agriculture.

On the Fort Ellis farm the soil moisture and soil nitrate studies are being conducted on virgin soil without irrigation. A variety of crops is being grown and their effect on the nitrates and moisture of the soil is determined. The chemistry and biology departments are cooperating on this problem.

The agronomy department is conducting a large amount of work over the State. It has immediate charge of some eighteen demonstration dry farms located in various sections of the State and two men are employed in superintending this work. At the Fergus County substation an extensive series of tests is being carried on in cooperation with the Bureau of Plant Industry, U. S. Department of Agriculture, in the study of dry farm crops and dry farm methods. We are also getting a report of the results obtained at the U. S. Government Station, located near Osborn in the Yellowstone Valley, where irrigated as well as dry farm crops are being grown.

Seepage studies were continued on the college farm, and a

new start made for field work on the duty of water. The plots have been leveled and the pipes laid so that water may be run to each plot without loss, the endeavor being to get an even distribution of water over the plot and to control absolutely the amount of water applied.

Animal Industry Department: The work of the animal industry department has broadened during the year, and plans have been laid for cooperation with the chemistry department for careful studies of clover and clover silage as fodder crops. Unfortunately the difficulty of securing chemical help has delayed these studies, but this problem has been solved for the time being and the work will proceed.

The department has now an excellent equipment in buildings and live stock. Feeding experiments with sheep, hogs, steers, and cows are being carried on. No bulletins have been published on the work, but during the year two circulars have been prepared and published, one on dairying and the other on hog management.

Good progress has been made in the wool investigation.

Chemistry Department: As in previous years the chemistry department has given most of its time to gathering data on problems taken up in cooperation with the other departments. In the soil nitrate studies they have been lending their aid to both the agronomy and biology sides of the problem.

Some valuable data have been gathered in the studies on incubation of eggs.

The meteorological observations have been continued during the year, and a large amount of work has been done on compiling data on the climate of the State from all the meteorological records available.

Horticultural Department: No new work has been undertaken during the year by the horticultural department. The tests of tree fruits, bush fruits, and vegetables have been continued, but more stress is being put on the effect of methods of cultivation and management.

Some interesting observations on the winter-killing of fruit buds will be put in form for publication this spring.

The horticultural substation in Ravalli County is in the charge of this department, and considerable time has been given to the

work at this place, and to making accurate notes on the growth of the orchard under different methods of soil management.

Veterinary Department: We have a small but well equipped veterinary laboratory. The materials required for the veterinary studies, however, are rather expensive and our funds have not been sufficient to push this work. Some study has been given to a few local outbreaks of hog cholera in various parts of the State, and the serum treatment has been used with success in checking the spread of this disease.

A manuscript has been prepared on some observations on contagious abortion in cattle, and some valuable observations made on the causes and transmission of infectious anaemia in horses.

Poultry Section: The work of the poultry plant was in excellent condition and some new and valuable lines of study were contemplated, when, about the middle of the year, an attractive offer was made to the poultryman to study for an advanced degree while working as an assistant in an eastern institution, and so he was granted leave of absence for a year. This compelled postponement of the new work for the present. A publication giving the results of our experience with the poultry plant for some years past will be issued in the near future.

MAILING LIST.

The names on the bulletin mailing list have increased faster the past year than at any previous period, there being now nearly 10,000 names. About 6,000 of these are from Montana, 2,500 from the colleges and experiment stations of other states, 1,200 from farmers and others in the various states, and about 200 from foreign countries. In addition to bulletins mailed to those on the regular list several thousand were sent on special request.

PUBLICATIONS OF THE YEAR.

For the past few years the Experiment Station has been giving especial emphasis to dry farm methods and crops. The State has an enormous area that can only be used for farming purposes by dry farm methods and a very large number of people have been and are coming to the State who have taken up homesteads on the bench lands and desire complete and accurate information

on how to handle these soils and what crops and crop management are necessary to get success on such lands. We have been trying to answer this need. With the increase in agricultural population there has also come a demand for information on many practical farm questions. To answer these inquiries we started two years or more ago a series of circulars. In these we aim to give practical information, based on observation and experience, on the best methods of agricultural practice in this State. As these circulars are not the results of definite experiments which are reported in our bulletins, their distribution is limited to Montana, to the libraries of the colleges and experiment stations, and to the newspapers on our lists.

For the year, four bulletins, nine circulars, and the eighteenth annual report have been published. The bulletins and the annual report contain 138 pages; the circulars 153 pages.

Bulletin No. 85, "Tick Control in Relation to Rocky Mountain Spotted Fever," by Prof. R. A. Cooley, is a report of cooperative investigations conducted by the Bureau of Entomology, of the U. S. Department of Agriculture, and the Montana Experiment Station. This bulletin gives the life history of the tick as far as known and a list of known hosts at different stages of development, and calls attention to the probable methods of controlling or eradicating the tick in the farming districts. Twenty-nine pages, edition 6,000.

Bulletin No. 86, "The Use of Soap to Retard the Settling of Certain Arsenicals," by Mr. J. R. Parker, records the results of several experiments in adding soap to standard arsenical sprays. Eleven pages, edition 6,000.

Bulletin No. 87. "Dry Farm Moisture Studies," by Prof. A. Atkinson, gives the results of four years' work on the dry farm substation near Forsyth, showing the result of methods of soil cultivation and cropping on the moisture content and movement of water in the first five feet of soil on a dry farm. Thirty-two pages, 15 charts, edition 5,000.

Bulletin No. 88, "Ninth Annual Report of the State Entomologist." This bulletin lists the large number of insect pests, which have been observed in the State or about which inquiry has been made as troubling the farm crops or fruits of the state.

Attention is also called to the prevalence of foul brood and the necessity for legislative control, and the present status of the spotted fever tick investigation is presented. The report closes with a copy of the Montana insecticide laws as passed by the last legislature. Twenty-six pages.

"Eighteenth Annual Report" is the Director's summary of the work of the year and contains also the financial statements, a list of available publications and brief summary of the year's meteorological records.

The circulars printed are numbered from 9 to 17, and make up the larger proportion of the publications of the year.

Circular 9, "Poultry Houses," by Asst. Prof. W. F. Schoppe, is a brief discussion of the location and arrangement of poultry houses, with three drawings showing methods of construction. Fifteen pages.

Circular 10, "Dairying in Montana," by Prof. R. W. Clark, deals particularly with milk production on the farms in Montana. Twenty pages.

Circular 11, "Navel-Ill in New Born Foals," by Dr. W. J. Taylor, calls attention to the danger from this disease and the care necessary to avoid it. Four pages.

Circular 12, "A Warning Against Fan Weed," by Prof. A. Atkinson and Prof. D. B. Swingle, points out the danger from this very bad weed, and gives a drawing from which any person should recognize it. Eleven pages.

Circular 13, "Hog Management in Montana," by Prof. R. W. Clark and Mr. H. P. Griffin. In this circular are described the methods of housing, feeding, and managing hogs under Montana conditions. Twenty-three pages, 8 cuts and drawings.

Circular 14, "Planting Trees and Shrubs on the Dry Farm," by Prof. O. B. Whipple, illustrates by drawing and description how to plant trees and shrubs around the home, and tells how to prepare the ground, and what trees, etc., to plant. Sixteen pages.

Circular 15, "Flax Growing in Montana," by Prof. F. S. Cooley and Mr. M. L. Wilson, gives very fully directions on the preparation of the soil, and seeding and harvesting the flax crop. Nineteen pages.

Circular 16, "The Pear-Leaf Blister Mite," by Mr. J. R. Parker,

calls attention to the serious injury done to fruit trees by this insect and indicates methods of control. Four pages.

Circular 17, "A Spraying Program for Montana Orchards," by Prof. R. A. Cooley and Prof. Deane B. Swingle. This circular gives directions for preparation of spray mixtures and the methods of applying the same to fruit trees to control the injury caused by the more common insect pests and plant diseases of the orchard in Montana. Appended to this report is a tabulation of the different spray mixtures—what to use them for and when to use them. Separate copies of this tabulated spray program may be had on application. Thirty-five pages, 12 drawings and cuts.

DONATIONS AND LOANS.

The following donations were made to the Experiment Station:
For the farm department:

One barrel sprayer by F. B. Connely of Billings, Mont.

One two-way disk by The Union Iron Works, Spokane, Wash.

One Melrose convertible wagon bed by American Wagon Co.,
Dixon, Ill.

One adjustable posthole auger by the Fern Manufacturing Co.,
Charlotte, Mich.

For the horticulture department:

Garden seeds by W. Atlee Burpee, Philadelphia, Pa.

Flower seeds by State Nursery Co., Helena, Mont.

Garden seeds by Bolgrain & Sons, Baltimore, Md.

Pruning shears by Detroit Shear Co., Detroit, Mich.

Hand Sprayer by Simplex Mfg. Co., Minneapolis, Minn.

Two hand sprayers by F. E. Myers & Bro., Ashland, Ohio.

PUBLICATIONS OF THE MONTANA EXPERIMENT STATION AVAILABLE FOR DISTRIBUTION.

NO. BULLETINS.

1. Organization—Announcements.
32. Eighth Annual Report.
33. Sugar Beets in Montana.
35. Report of Feeding Tests.
36. Forage Conditions in Montana.
38. Food Adulteration.

41. Sugar Beets.
42. The Codling Moth.
Ninth Annual Report.
44. Apple Growing in Montana.
45. Loco and Some Other Poisonous Plants in Montana.
46. Two Insect Pests.
47. Sheep Feeding.
48. Steer Feeding.
49. Contagious Abortion in Montana.
Tenth Annual Report.
52. Sugar Beets.
53. Creameries and Cheese Factories.
62. Third Annual Report of State Entomologist.
70. The Douglas Fir Cone Moth.
71. Fifth Annual Report of State Entomologist.
73. Pig Feeding Experiments.
75. Sixth Annual Report of State Entomologist.
Fifteenth Annual Report.
77. Fruit Tree Planting in Montana.
78. Steer Feeding Experiments.
Sixteenth Annual Report.
80. Ornamental Trees and Shrubs for Montana.
81. Destruction of Hydraulic Cements by the Action of Alkali Salts.
83. Dry Farming Investigations in Montana.
84. Grain Investigations with Wheat, Oats and Barley.
Seventeenth Annual Report.
85. Tick Control in Relation to Rocky Mountain Spotted Fever.
86. Use of Soap to Retard Settling of Certain Arsenicals.
87. Dry Farm Moisture Studies.
88. Ninth Annual Report of State Entomologist.
Eighteenth Annual Report.

NO. CIRCULARS

2. The Pear and Apple Blight in Montana.
3. Dry Farming Practice in Montana.
4. The Army Cutworm.
5. Alfalfa Management in Montana.

6. Flax Growing in Montana.
7. Water Analysis in Montana.
8. Action of Alkali on Hydraulic Cements.
9. Poultry Houses.
10. Dairying in Montana.
11. Navel-Ill in New-Born Foals.
12. A Warning Against Fan Weed.
13. Hog Management in Montana.
14. Planting Trees and Shrubs on the Dry Farm.
15. Flax Growing in Montana.
16. The Pear-Leaf Blister-Mite.
17. A Spraying Program for Montana Orchards.

WEATHER RECORD.

SUMMARY BY MONTHS FOR THE YEAR 1911.

Edmund Burke, Meteorologist.

	Highest temperature	Lowest Temperature	Mean temperature	Precipitation	Clear days	Partly cloudy days	Cloudy days	Days with 0.01 of an inch or more precipitation	Direction of prevailing winds
January	48	-24	21.3	1.67	7	9	15	7	SW.
February	47	-10	17.4	0.33	12	9	7	4	SE.
March	63	- 2	37.1	0.05	19	10	2	3	SW.
April	68	15	38.5	1.57	8	15	7	7	NW.
May	80	27	47.4	3.56	5	21	5	10	SE.
June	83	32	58.7	3.06	12	17	1	15	SE.
July	88	35	60.9	0.84	12	19	0	6	SE.
August	87	36	58.3	1.52	17	13	1	6	SE.
September	85	29	57.1	0.91	9	13	8	8	SE.
October	74	15	38.9	2.15	12	16	3	7	SW.
November	55	-15	25.9	1.12	4	23	3	6	SW.
December	47	-21	20.6	0.65	3	19	9	8	SE.
For the year			40.2	17.43	120	184	61	87	

SUMMARY FOR THE YEAR 1911.

Highest temperature88, July 6th.
Lowest temperature-24, January 2nd.
Greatest range112.
Highest monthly mean60.9, July.
Lowest monthly mean17.4, February.
Highest daily mean70.5, July 6th.
Lowest daily mean-13.5, December 29th.
Greatest total precipitation for one month3.56, May.
Last killing frostJune 5th.
First killing frostSeptember 6th.

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**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION**

F. B. LINFIELD, Director



**Nineteenth
Annual Report**
FOR THE FISCAL YEAR ENDING
JUNE 30, 1913

BOZEMAN, MONTANA
FEBRUARY, 1913

MONTANA AGRICULTURAL COLLEGE

EXPERIMENT STATION

BOZEMAN, MONTANA

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 G. E. SMITH, *Assistant Chemist*.
 HAROLD H. MORRIS, A. B., *Assistant Chemist*.

NOTICE—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all the publications are desired as issued or only those specified. Give name and address plainly.

All communications to the Experiment Station should be addressed to
THE MONTANA EXPERIMENT STATION,
Bozeman, Montana.

LETTER OF TRANSMITTAL

Bozeman, Montana, January 31, 1913.

To His Excellency, Samuel V. Stewart,

Governor of Montana.

Dear Sir:

In accordance with the Congressional Acts of March 2, 1887, and March 16, 1906, I have the honor to transmit herewith the Nineteenth Annual Report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1912; the results of investigations of the several departments are reported to the end of the state year, November 30, 1912.

Very respectfully,

F. B. LINFIELD, Director.

REPORT OF THE TREASURER

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriations 1910-1911.

Dr.		
	Hatch Fund	Adams Fund
To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1912, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906(Adams Fund)....	\$15,000.00	\$15,000.00
Cr.		
By salaries.....	\$11,150.00	\$10,840.00
Labor	1,408.40	1,226.93
Publications	606.36	
Postage and stationery.....	498.35	67.71
Freight and express.....	127.93	96.63
Heat, light, water, and power.....	78.88	11.15
Chemical supplies.....	16.50	506.32
Seeds, plants and sundry supplies..	195.52	255.86
Fertilizers .....	.....	.....
Feeding stuffs.....	289.90	113.40
Library	175.84	83.10
Tools, implements and machinery..	106.63	577.08
Furniture and fixtures.....	2.50	57.39
Scientific apparatus.....	19.09	341.34
Live stock.....	9.00	60.00
Traveling expenses.....	84.00	570.78
Contingent expenses	25.00	.....
Buildings and land.....	206.10	192.40
Balance .....	.....	.....
	<hr/>	<hr/>
Total.....	\$15,000.00	\$15,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and

accounts of the Experiment Station of the Agricultural College of the State of Montana, for the fiscal year ending June 30, 1912; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$15,000.00 under the act of Congress of March 2, 1887, and \$15,000.00 under act of Congress of March 16, 1906, and the corresponding disbursements \$15,000.00 and \$15,000.00, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts.

Respectfully,

Signed:

J. H. BAKER,

J. F. BLAIR,

Auditors.

Attest: G. R. CALLAWAY, Custodian.

EXPERIMENT STATION MISCELLANEOUS FUND

Dr.	State appropriation	Farm products	Total
To receipts from other sources than the United States for the year ended June 30, 1912.....			
	\$55,663.45	\$6,845.33	\$62,508.78
Cr.			
By salaries.....	\$7,400.00	\$112.50	\$7,512.50
Labor	15,746.44	4,381.96	20,128.40
Publications	1,830.66	24.35	1,855.01
Postage and stationery.....	467.92	74.54	542.46
Freight and express.....	954.22	108.06	1,062.28
Heat, light, water, power.....	1,493.54	132.10	1,625.64
Chemical supplies.....	201.62	16.50	218.12
Seeds, plants and sundry supplies....	2,051.37	753.88	2,805.25
Fertilizers .....	.....	.....	.....
Feeding stuffs.....	1,219.30	122.56	1,341.86
Library	24.40		24.40
Tools, implements and machinery....	1,168.77	238.75	1,407.52
Furniture and fixtures.....	430.33	48.50	478.83
Apparatus	119.59	109.35	228.94
Live stock.....	402.50		402.50
Travelling expenses.....	4,577.75	237.35	4,815.10
Contingent expenses.....	83.90	293.50	377.40
Buildings and land.....	17,491.14	191.43	17,682.57
Total.....	\$55,663.45	\$6,845.33	\$62,508.78

Report of the Director

During the past season Montana has had probably the largest crop in the history of the State. While in some of the higher valleys the season was a little short for the best results, yet over most of the bench lands that have within the past few years been put under the plow the crops were excellent. This was due to favorable weather conditions with a virgin soil. The good crops, however, were shared by most of the farmers of the United States and so prices for grain were considerably below those of the previous year. This condition points to the necessity for a return to the live stock industry on which the State prided itself for so many years.

The present situation calls for some difference in the class of live stock kept, as the poultry, the hog, and the dairy cow will find as large a place on the farm as the beef cattle and sheep found upon the range. In the past, because of the limited production, Montana farmers frequently got eastern prices plus the freight for their hay and grain, but with the recent agricultural development that time is gone never to return. Plans, therefore, should be made at once to diversify the farm crops and produce more of live stock and live stock products.

The Experiment Station has been looking forward to this change and gathering a large fund of information on methods of feeding and the care of all classes of live stock under Montana farm conditions. We have recently issued bulletins and circulars on hog feeding and management and on dairying, and have others in preparation on poultry management, sheep on the farm, etc.

IMPROVEMENTS

The \$4,000.00 appropriated by the State for sheds and a silo became available during the year. With that fund one building 122 feet long with 12-foot posts was erected. One end of this building is arranged for the use of the horticulture department with cellar, work and tool floor, and loft. On the other end of

the building is a repair shop and the office of the farm foreman. Between these two is a shed 66 feet long with a cement floor for the accommodation of farm machinery, traction engines, etc.

A wagon shed 64 feet long was also constructed south of the sheep barn.

A cement silo 15 feet inside diameter and 33 feet high was built south of the cattle barn.

SUBSTATIONS

The dry farm substation in the Judith Basin was crossed by a hail storm about the time the spring crops were beginning to head, which destroyed practically all the spring grain and seriously injured the fall wheat. The results this year, therefore, were quite unsatisfactory. During the year the remainder of the section, about 450 acres, was leased from the State. About 200 acres of the land had been broken, and 50 acres of this has been put into additional experimental crops. A bulletin is in preparation giving the results so far attained at this station and an outline of the work we have in hand. The cooperative arrangement with the U. S. Department of Agriculture is being continued.

The annual picnic at this station brought together nearly 4,000 people from all parts of the valley and from surrounding country. This was a larger attendance than for any previous year.

The Huntley substation was started and is carried on by the U. S. Department of Agriculture. It comprises about 160 acres of land partly below and partly above the irrigation canal. The whole time of the station is given to crop studies on irrigated and dry land. The Montana Experiment Station contributed \$720.00 last year for the support of this station and received a full report of the data gathered. This work has not yet progressed far enough to report results.

There is nothing new to report from the horticultural substation in the Bitter Root Valley. The trees are growing well and many of them coming into bearing. The tract is now practically all planted.

COOPERATIVE PLANS

The Experiment Station has cooperated during the year with the U. S. Department of Agriculture, Bureau of Plant Industry.

through the dry farm and grain investigation offices; also with the Irrigation Division and the Bureau of Entomology. This cooperation has given funds and expert workers to the State, that have materially increased the experimental studies we were able to make.

The Flax Development Committee of the Linseed Oil Consumers also contributed \$2,000.00 to studies and instruction on flax growing in the newer agricultural districts of the State.

AGRICULTURAL EXTENSION

The Experiment Station work connects very closely with the work of the farmer in many directions. As a result we have a very lively interest in the agricultural extension work. The director is a member of the Farmers' Institute Board and several of the Station staff have given lectures at farmers' meetings in various parts of the State. The calls, however, have not been burdensome as most of the institute work has been done by men engaged especially for the field work.

CORRESPONDENCE

The station continues to carry on a large correspondence in answer to requests for information. During the year between 12,000 and 13,000 letters were received and answered. About 4,000 of these letters were answered by sending a bulletin or circular.

Nineteen demonstration farms have been cared for during the year. Many of these have served a very useful purpose in the community where located, but we believe that most of them have now served their purpose. During the coming two years it is planned to substitute the farm demonstrator for the demonstration farm, after which time we hope the work will be taken over by the extension department of the college.

As soon as the State can afford it, however, I believe it would be advisable to establish two or three more permanent field crop stations. Montana covers a very large area and has a great variety of climatic conditions. The stations at present in operation cover the central and southern part of the State, but stations should be started in other sections where climatic, soil and crop conditions are considerably different from the south country. I would like

to see sub-experiment stations started first in the north central part of the State, second in the Flathead district, either north or south of Flathead Lake, and a third in the eastern part of the State somewhere along the line of one of the new railroads going through Dawson county. This district is somewhat beyond the successful fall wheat belt and thus has a different crop problem from the country farther west. With these three additional sub-stations, practically all the climatic districts of the State would be covered. The work, however, should be confined to crop studies only, though both irrigated and dry-farm crops should be grown.

WORK OF THE YEAR

Biology.—The biology department has had a busy year. The entomological division has continued its studies on the oyster shell scale, but has still further work to do to clear up all the facts necessary to its more complete control.

The studies on sugar beet insects were confined largely to the sugar beet root louse. For several years the entomologist has been looking for the sexual forms of this insect, and during the past season the efforts in this direction were rewarded. These sexual forms are being studied and will be reported on later. Studies in the laboratory, supplemented by observations in the field, indicate that the injury by the louse may be largely controlled by the methods of irrigating; the louse does not seem to thrive in moist soil.

Miscellaneous observations have been made on a new currant pest, on a new thrips of the gooseberry and currant, and a new enemy of the aphids.

The botanical division of this department continued its studies on the bark and wood diseases of orchard trees, particularly the cankers, collar rot, black heart, and wood rots. Additional facts as to the development of these diseases were obtained, but no control methods can yet be recommended.

The most extensive work of this division during the year was with the problem on the effect of arsenical compounds upon vegetation. Work was carried on with orchard trees, with a variety of grain and fodder crops, with vegetables, and with plants in

the greenhouse. Valuable information has been gained but much additional work yet remains to be done.

The work in soil bacteriology has been given largely to a test of methods. As a result probably some modifications of the problem will have to be made.

Some general observations have been made on apple scab and on crown galls. Two diseases new to the State have been found, viz, the sorghum smut and the pear scab.

Agronomy.—The agronomy department has a large number of projects on hand but they divide into three main groups: first, the Adams projects of which there are three; next, the crop experiments on the college farm and at Fort Ellis; and, lastly, the soil and crop studies carried on over the State. Satisfactory progress was made with the Adams projects, but no definite results can be reported.

The results from the field crop studies were not very satisfactory the past season as the spring was very late, the summer cool and the fall quite wet. Progress was made, however, in some directions, but another year's work is necessary to get definite results.

The agricultural engineering division of the agronomy department gave the most of its attention to a pumping test, using various sizes and types of traction engines, different kinds of fuel, and different pumps. Tests were made of lifts varying from 10 feet to 50 feet.

Animal Husbandry.—The work in the animal husbandry department is becoming better organized year by year, and some interesting and valuable bulletins have been prepared during the year. Others will be ready early in the coming year.

As the result of the studies made the previous year in cooperation with the professor of mathematics of the college, a special apparatus was devised for the testing of wool fibers, which has given very satisfactory results. This makes possible the next phase of the studies with wool.

The observations on the growth of young beef cattle raised on the farm have been continued.

The results of this year's work on feeding clover silage to

cows have been prepared for publication, and other studies on the feeding value of clover started.

A large number of tests have been carried on with hogs and the results of some of these will be reported on during the coming year. One bulletin on pig feeding and a circular on feeding and management of hogs were prepared by the department and published during the year.

Chemistry.—As in past years the chemical department has given considerable time to projects taken up in cooperation with other departments. In the soil nitrate studies over 3,000 determinations were made.

Studies of infertile soils were taken up with the agronomy department. To people who inquired, the offer was made to analyze any infertile soils, provided the samples were taken according to directions and other information provided. This has given facts about certain soils which will be followed up with more complete studies.

A study of clover hay and clover silage has been taken up in cooperation with the animal industry department, and progress has been made on this project.

The studies on the natural and artificial incubation of eggs have been continued. Special attention has been given to the temperature of incubation and the composition of the shell of the egg and its contents at various stages of incubation.

The department has been working on the meteorological data of the State during the year and has nearly ready for publication a comprehensive study of Montana climate.

Horticulture.—The horticultural department has made good progress in its work for the year. At the home station observations have been continued on a large variety of small fruits and notes made on results from different methods of handling them.

On the tree fruits no new work was done but plans are being made for the removal of some of the old trees and the planting of new stock.

Further studies have been made on a large variety of trees and shrubs both in the nursery and on the college campus. Some new varieties are being planted. Interesting and valuable observa-

tions were made on the relation of leaves on the fruit spurs of the apple to the size and maturing of the fruit. Observations were also made on serious injury resulting to young trees from painting the trunks with lard and sulphur. While this preparation protects the trees from rabbits it seems in very many cases to kill the tree.

An extensive series of tests with vegetables is being carried on; several varieties of beans, peas, cabbages, cauliflowers, onions, celery, and tomatoes are being tested. Whenever possible seed grown at the station is compared with seed from other sources.

The department is just starting a series of tests with potatoes including the testing of varieties and of cultural methods.

Veterinary.—The veterinary department has supervision over the health of all the live stock on the farm and is in full charge of all sick animals.

During the year one bulletin has been prepared as a result of studies on the prevention of contagious abortion.

No progress was made on the study of infectious anemia as but few animals were reported as affected.

A series of tests was made with whole and skim milk preserved with varying amounts of formaldehyde, preliminary to taking up the feeding of formalin-treated milk to calves.

Poultry.—The poultry work has been a continuation of that of previous years,—a study of methods of feeding, housing and caring for the chick, and of the results to be had under Montana conditions. The head of this work has been away on leave of absence for a whole year.

MAILING LIST

The station is now publishing 13,000 bulletins in its regular edition, and the names on the regular mailing list number about 11,000. Of these about 7,000 are citizens of Montana.

In addition to the bulletins sent to those on the regular mailing list six thousand to eight thousand bulletins were sent out on special request.

PUBLICATIONS OF THE YEAR

Since the last report four bulletins, eight circulars, and the nineteenth annual report have been published. The bulletins contain 65 pages and the circulars 199 pages.

Bulletin No. 89, "Experiments with Pigs," by Prof. R. W. Clark, is a report on feeding pigs on various grains and combinations of grains and other food stuffs. Sixteen pages.

Bulletin No. 90, "The Internal Use of Carbolic Acid for the Prevention of Contagious Abortion in Cattle," by Dr. W. J. Taylor, reports the results of the use of carbolic acid with a number of herds. Sixteen pages, 5 illustrations.

Bulletin No. 91, "Winter Injury to Fruit Buds of the Apple and the Pear," by Prof. O. B. Whipple, reports the results of observations made during the winter of 1910-11 on the winter-killing of the embryo fruit buds without, however, killing the leaves in the bud. In some cases the sexual organs of the embryo flower were killed, yet the fruit developed, though abnormal in shape. Thirteen pages, 5 plates.

Bulletin No. 92, "Tenth Annual Report of the State Entomologist," by Prof. R. A. Cooley, is a report on the important troublesome pests of the year together with recommendations as to the needs of the work. Twenty pages, one plate.

Circulars.—The circulars are popular publications intended to give practical information on a variety of topics of interest to the farmers in various parts of the State.

Circular 18, "Chick Feeding," by W. F. Schoppe, outlines several rations for small chicks. Six pages.

Circular 19, "Suggestions to the Dry Farmer," by Prof. F. S. Cooley, is a brief but comprehensive statement of the problem and practice of dry farming. Fifty-two pages.

Circular 20, "The Control of Prairie Dogs and Ground Squirrels," by M. Herrick Spaulding, explains how to destroy them by poisoning or fumigation. Eighteen pages.

Circular 21, "The Roller or Packer," by H. B. Bonebright, describes a home made roller and packer suitable for packing new ground. Six pages, 6 illustrations.

Circular 22, "Cropping to Flax on New Lands of Semi-Arid Land Areas," by M. L. Wilson and H. L. Bolley, describes the method of treating the seed and preparing the seed bed for the flax crop. Thirty-one pages, 26 illustrations.

Circular 23, "Creamery Organization and Management," by R. C. Jones. Eight pages.

Circular 24, "Measurement of Water," by R. D. Kneale. This is a revision of Bulletins No. 34, "Farmers' Weirs," and No. 72, "Measurement of Water." It is not intended for general distribution but to supply the requests for information on methods of measuring irrigation water. Fifty-eight pages, 19 illustrations.

Circular 25, "Cabbages and Cauliflowers in Montana," by L. G. Schermerhorn, is a brief description of how to grow these vegetables. Twelve pages, 6 illustrations.

Circular 26, "Celery Culture in Montana," by Prof. O. B. Whipple. Eight pages.

PUBLICATIONS OF THE MONTANA EXPERIMENT STATION AVAILABLE FOR DISTRIBUTION

- | No. | BULLETINS |
|-----|---|
| 32. | Eighth Annual Report. |
| 33. | Sugar Beets in Montana. |
| 35. | Report on Feeding Tests. |
| 42. | The Codling Moth. |
| | Ninth Annual Report. |
| 45. | Loco and Some Other Poisonous Plants in Montana. |
| 46. | Two Insect Pests. |
| 47. | Sheep Feeding. |
| 48. | Steer Feeding. |
| | Tenth Annual Report. |
| 52. | Sugar Beets. |
| 70. | The Douglas Fir Cone Moth. |
| 71. | Fifth Annual Report of the State Entomologist. |
| | Fourteenth Annual Report. |
| 73. | Pig Feeding Experiments. |
| 75. | Sixth Annual Report of the State Entomologist. |
| 76. | Seepage and Drainage. |
| | Fifteenth Annual Report. |
| 78. | Steer Feeding Experiments. |
| | Sixteenth Annual Report. |
| 80. | Ornamental Trees and Shrubs for Montana. |
| 81. | Destruction of Hydraulic Cements by the Action of Alkali Salts. |

82. Eighth Annual Report of the State Entomologist.
83. Dry Farming Investigations in Montana.
84. Grain Investigations with Wheat, Oats and Barley.
Seventeenth Annual Report.
87. Dry Farm Moisture Studies.
88. Ninth Annual Report of the State Entomologist.
89. Experiments with Pigs.
90. Use of Carbolic Acid for Prevention of Contagious Abortion.
91. Winter Injury to Fruit Buds of Apple and Pear.
92. Tenth Annual Report of the State Entomologist.
Nineteenth Annual Report.

No.

CIRCULARS

2. The Pear and Apple Blight in Montana.
3. Dry Farming Practice in Montana.
4. The Army Cutworm.
5. Alfalfa Management in Montana.
6. Flax Growing in Montana.
7. Water Analyses in Montana.
8. Action of Alkali on Hydraulic Cements.
9. Poultry Houses.
10. Dairying in Montana.
11. Navel-Ill in New-Born Foals.
12. A Warning Against Fan Weed.
13. Hog Management in Montana.
14. Planting Trees and Shrubs on the Dry Farm.
15. Flax Growing in Montana.
16. The Pear-Leaf Blister-Mite.
17. A Spraying Program for Montana Orchards.
18. Chick Feeding.
19. Suggestions to the Dry-Farmer.
20. Control of Prairie Dogs and Ground Squirrels.
21. The Roller or Packer.
22. Cropping to Flax on New Lands of Semi-Arid Land Areas.
23. Creamery Organization and Management.
24. Measurement of Water.
25. Cabbages and Cauliflowers in Montana.
26. Celery Culture in Montana.

DONATIONS AND LOANS

- 1 14-inch gang plow by Independent Harvester Co., A. J. Holloway, Agent, Bozeman, Montana.
- 100 pounds nitrate of soda, Dr. W. S. Myers of the Nitrate of Soda Propaganda.
- Garden seeds, W. Atlee Burpee, Philadelphia, Pa.
- Garden seeds, Bolgians & Sons, Baltimore, Md.
- Plants, Henry Dreer, Philadelphia, Pa.
- Nursery trees, Missoula Nursery Co., Missoula, Mont.
- 1 Titan tractor, International Harvester Co., Helena—For pumping experiment and college.
- 1 Foston smut cleaner, Foston Mfg. Co., St. Paul, Minn.—College and farm.
- 1 spring tooth harrow, Bucher & Gibbs Plow Co., Canton, Ohio—College and agronomy department of station.
- 1 75 h. p. Case engine, J. I. Case Co., Billings—College and pumping experiment.
- 1 Big 4 -30 (available for tests), Gas Traction Co., Billings—College and pumping experiment.
- 1 Detroit gas engine, Detroit Engine Works, Detroit, Mich.—College and farm.
- 1 Hoyland wild oat separator, Klauer Mfg. Co., Dubuque, Ia.—College and farm.
- 1 Champion potato planter, Champion Potato Machinery Co., Hammond, Ind.—College and horticultural department of station.
- 1 Thomas drill, Thomas Mfg. Co., Springfield, Ohio—College and agricultural engineering tests.
- 1 Friend spray motor, Friend Mfg. Co., Gasport, N. Y.—College, biology and horticulture departments of station.
- 1 Packer attachment for plow, Wilburg Plow Attachment Co., Nome, N. D.—College and farm.
- 1 5-inch Byron Jackson pump, Byron Jackson Iron Works, San Francisco—Pumping experiment.
- 1 7-inch American pump, American Well Works, Aurora, Ill.—Pumping experiment.
- 1 3-inch Gould pump, Gould Mfg. Co., Seneca Falls, N. Y.—Pumping experiment.

- 1 20-40 h. p. Case gas engine, J. I. Case Co., Billings—College and pumping experiment.
- 1 Holt Caterpillar 60 h. p. engine, Holt Mfg. Co., Great Falls, Mont.—College and pumping experiment.
- 2 J. I. Case dump wagons, J. I. Case Co., Billings—College, road school.
- 1 Perfection road grader, J. I. Case Co., Billings—College, road school.
- 1 Road drag, J. I. Case Co., Billings—College, road school
- 1 Case engine tender, J. I. Case Co., Billings—College, road school and pumping experiment.
- 1 Fuller & Johnson pump engine, Fuller & Johnson Co., Madison, Wis.—College and farm.
- 1 Iron Age potato planter, Bateman Mfg. Co., Grenloch, N. J.—College and horticultural department of station.
- 1 Iron Age potato cultivator, Bateman Mfg. Co., Grenloch, N. J.—College and horticultural department of station.
- 1 Spalding deep tilling machine, Spalding Deep Tilling Machine Co., Cleveland, Ohio—College and agricultural engineering tests.
- 1 Two-way J. I. Case plow (ordered shipped), F. B. Connelley, Billings—College and farm.
- 1 Potato sprayer, F. B. Connelley, Billings—College and farm.
- 1 pound arsenate of lead, Hemingways London Purple Co., Limited, New York.
- 30 pounds arsenate of lead, A. B. Ansbacher & Co., New York.
- 3 pounds arsenate of lead, Grasselli Chemical Co., Cleveland, Ohio.
- 1 pound arsenate of lead, Sherwin-Williams Co., Cleveland, Ohio.
- 2 pounds arsenate of lead, Bean Spray Pump Co., San Jose, Calif.
- 5 pounds arsenate of lead, Fred L. Lavanburg, New York.
- 2 pounds arsenate of lead, Merrimac Chemical Co., Boston, Mass.
- 30 pounds arsenate of lead, Better Spray Co., Portland, Ore.
- 1 gallon combined fungicide and insecticide, 2 quarts Calite, 1 quart Herrmann's Arsoid, Morris Herrmann & Co., New York.
- 1 pound arsenate of lead, Corona Chemical Co., Milwaukee, Wis.
- 12½ pounds arsenate of lead, Dow Chemical Co., Midland, Mich.
- 5 pounds arsenate of lead, Bowker Insecticide Co., Boston, Mass.
- 10 pounds soluble sulphur, Niagara Spray Co., Middleport, N. Y.
- 5 pounds arsenate of lead, Adler Chemical Works, New York.

WEATHER RECORD

SUMMARY BY MONTHS FOR THE YEAR 1912
Edmund Burke, Meteorologist

	Highest temperature	Lowest temperature	Mean temperature...	Precipitation	Clear days.....	Partly cloudy days..	Cloudy days.....	Days with 0.01 of an inch or more precipitation	Direction of prevailing winds.....
January	48	-14	22.0	.92	5	18	8	7	SE
February	48	-3	27.0	.39	5	17	7	9	SE
March	50	6	18.8	1.86	12	17	2	7	SE
April	66	20	43.9	3.59	9	17	4	10	SE
May	78	27	47.6	2.66	7	17	7	11	SW
June	86	34	58.7	2.69	13	14	3	7	SW
July	87	41	59.9	1.91	16	12	3	12	NE
August	87	33	58.7	1.63	19	5	7	11	SE
September	73	23	46.4	1.66	13	7	10	8	SE
October	72	16	37.9	3.23	12	6	13	10	SE
November	58	12	36.1	.37	7	6	17	2	SW
December	46	3	23.0	.74	13	11	7	6	SE
For the year..			40.0	21.65	131	147	88	100	

SUMMARY FOR THE YEAR 1912

Highest temperature.....87°, July 25th and August 26th
Lowest temperature.....-19°, January 2nd
Greatest range.....106°
Highest monthly mean.....59.9°, July
Lowest monthly mean.....18.8°, March
Highest daily mean.....71.5°, July 25th
Lowest daily mean.....-5.5°, February 6th and 7th
Greatest total precipitation for one month.....3.59 in., April
Last killing frost.....May 28th
First killing frost.....September 15th

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**MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION**

F. B. LINFIELD, Director



**Twentieth
Annual Report**
FOR THE FISCAL YEAR ENDING
JUNE 30, 1913

BOZEMAN, MONTANA
February 1914

MONTANA AGRICULTURAL COLLEGE

EXPERIMENT STATION

BOZEMAN, MONTANA

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 E. L. CURRIER, B. Sc., *Asst. Farm Management*
 B. W. WHITLOCK, B. S., *Superintendent Grain Laboratory*
 M. L. WILSON, B. S. A., *County Agriculturist*
 CARL H. PETERSON, *County Agriculturist*

* Absent on leave.

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all the publications are desired as issued or only those specified. Give name and address plainly. All communications to the Experiment Station should be addressed to
 THE MONTANA EXPERIMENT STATION,
 Bozeman, Montana.

LETTER OF TRANSMITTAL

Bozeman, Montana, January 31, 1914.

To His Excellency, Samuel V. Stewart,
Governor of Montana.

Dear Sir:

In accordance with the Congressional Acts of March 2, 1887, and March 16, 1906, I have the honor to transmit herewith the Twentieth Annual Report of the Montana Experiment Station. The financial statement is for the year ending June 30, 1913; the results of investigations of the several departments are reported to the end of the State year, November 30, 1913.

Very respectfully,

F. B. LINFIELD, Director.

REPORT OF THE TREASURER

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriations 1912-13.

Dr.		
	Hatch Fund	Adams Fund
To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1913, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund).....		
	\$15,000.00	\$15,000.00
Cr.		
By salaries.....	\$11,783.33	\$11,658.33
Labor	1,426.82	1,562.50
Publications	361.59	.....
Postage and stationery.....	449.39	34.66
Freight and express.....	107.35	191.79
Heat, light, water, and power.....	40.32	1.20
Chemical supplies.....	109.46	236.47
Seeds, plants and sundry supplies..	188.83	136.75
Fertilizers .....	.....	.....
Feeding stuffs.....	196.12	61.00
Library	40.25	36.93
Tools, implements and machinery..	93.74	25.99
Furniture and fixtures.....	15.50	48.40
Scientific apparatus.....	18.50	190.34
Live stock.....	21.35	300.00
Traveling expenses.....	147.45	441.85
Contingent expenses.....	.....	.....
Buildings and land.....	.....	73.79
Total.....	\$15,000.00	\$15,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana, for the fiscal year ending June 30, 1913; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$15,000.00 under the act of Congress of March 2, 1887, and \$15,000.00 under act of Congress of March 16, 1906, and the corresponding disbursements \$15,000.00 and \$15,000.00, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts.

Respectfully,

Signed:

J. H. BAKER,
W. S. DAVIDSON,
Auditors.

Attest: G. R. CALLAWAY, Custodian.

EXPERIMENT STATION MISCELLANEOUS FUND

Dr.	State appropriation	Farm products	Total
To receipts from other sources than the United States for the year ended June 30, 1913.....			
	\$22,581.35	\$7,000.00	\$29,581.35
Cr.			
By salaries.....	513.00	-----	513.00
Labor	11,430.70	3,901.90	15,332.60
Publications	1,514.47	-----	1,514.47
Postage and stationery.....	630.54	18.85	649.39
Freight and express.....	290.39	61.66	352.05
Heat, light, water, power.....	1,456.33	70.30	1,526.63
Chemical supplies.....	225.08	-----	225.08
Seeds, plants and sundry supplies.....	2,027.10	603.19	2,630.29
Fertilizers	-----	-----	-----
Feeding stuffs.....	872.11	.65	872.76
Library	59.90	8.00	67.90
Tools implements and machinery.....	667.92	82.80	750.72
Furniture and fixtures.....	373.05	27.50	400.55
Apparatus	91.27	200.00	291.27
Live stock.....	861.90	1,050.00	1,911.90
Travelling expenses.....	369.23	410.10	779.33
Contingent expenses.....	50.00	314.50	364.50
Buildings and land.....	1,148.36	98.10	1,246.46
Balance	-----	152.45	152.45
<hr/>			
Total.....	\$22,581.35	\$7,000.000	\$29,581.35

Report of the Director

The Agricultural Experiment Station was established by an act of the State legislature, approved February 16th, 1893. It is thus twenty years since the Experiment Station was organized and its work started. Because of this it seems appropriate to call attention at this time to a few facts concerning the growth and work of the institution since its organization.

The law established the Experiment Station at Bozeman, Gallatin County, and donated 160 acres of land for an experiment farm; and the Hatch fund from the Federal Government provided \$15,000 per year for the maintenance of the work. Out of this fund and the proceeds from farm products was provided the buildings and equipment needed for carrying on the work for the first ten years.

The Station staff at the beginning consisted of four men, the director, who was also horticulturist, an agriculturist and botanist, a chemist, and a veterinary surgeon. One year later an irrigation engineer was added. None of these men are at present in the employ of the Station; the last one to sever his connection resigned in the autumn of 1903.

This first ten-year period might be called the pioneer stage of the work, during which the Station made a place for itself and demonstrated its possibilities. The people as a whole had not yet awakened to the great agricultural possibilities of the State.

In the spring of 1903 began what might be called the constructive period of the Station's development. The legislature of that winter appropriated \$16,000 for the construction of farm buildings and gave the first appropriation for general maintenance to supplement the United States Government funds. These appropriations have been kept up and increased, so that during the next ten years, or up to the spring of 1913, \$135,000 had been given for buildings and improvements for the agricultural work, and the State maintenance fund now amounts to \$37,000 per year. In addition to this, \$15,000 has been put into permanent equipment at substations, and the funds for their maintenance and for other work over the State have increased to \$23,000 per year.

Within the past ten years the funds from the United States Government have been doubled, making \$30,000 per year from this

source. The total income from all sources for 1913-14 was \$107,000.

At the beginning of this period the farm land consisted of the original 160 acres. Some five years ago an additional 160 acres was purchased and the State turned over to the custody of the institution the 640 acres in the Fort Ellis military reservation. This gives 960 acres at the home station, not including the college campus. At the substations 180 acres of land have been given to the State.

Summing up the changes for the past ten years, we find that at the beginning of this period the Station staff numbered seven men. It now numbers twenty-two, representing nearly all phases of agricultural work. The land area has been multiplied seven times; the buildings and equipment, measured by their cost, have multiplied ten times. The maintenance appropriation for the work has multiplied five and one-half times.

During this same ten years the people's ideas as to the agricultural possibilities of the State have been revolutionized. The land below the ditch has nearly doubled and the projects in hand and proposed will double the present irrigated area within a few years. The crop-producing possibilities of millions of acres of bench-lands have been demonstrated, and thousands of settlers are now making their homes on this land. Large business concerns have shown their interest in this work by giving thousands of dollars to aid in farm demonstration. The Experiment Station has received \$65,000 from other than State or Federal sources during the past ten years.

The results from these demonstrated agricultural possibilities are now being realized. It is faith in the agricultural wealth of Montana that has constructed the hundreds of miles of new railroads in the State within the past ten years, and it is the development of the agricultural resources which is leading these railroads to construct hundreds of miles of additional lines as fast as they can raise the money for the work. It is this same faith in the agriculture of Montana which has added scores of new towns along the old lines of railway and increased greatly the population of the old ones. It has also built scores of new towns along the new lines of railroads, and the end is not yet.

This agricultural development has nearly doubled the assessed valuation of the State in ten years and also has made it possible

for the State to sell its own lands rapidly and at maximum prices. The increase in land values and in assessment has already returned to the State many times what it has put into this agricultural development and the returns will multiply rapidly within the next few years.

The Experiment Station has had a part in this development by pointing out the agricultural possibilities and showing how they could be safely used. We feel, however, that there is now another problem demanding attention. We must delve deeper into the farm problems. It is ours to assist in showing the new and the old settler the way to get the most out of his farm and the farm life, and to point the way to the building of a permanent agriculture in the State. From the Experiment Station standpoint we will have to dig deeper into the scientific problems underlying our agriculture, in order that we may lay that deep, broad, and safe basis necessary to the highest type of successful agriculture. Thus we will need men of great scientific attainment, deep, broad, and thorough in their training, and enthusiastic in their work. We should begin a new era in our development as an agricultural experiment station and put more stress on our scientific research work.

Agriculture is a growing science. Not alone are the four main divisions,—animal husbandry, dairying, agronomy, and horticulture—dividing into specialties, but we are also adding to these divisions. Thus we have agricultural engineering, dealing with the mechanical, civil, and electrical engineering problems of the farm. Then there is farm management, which is defined as the “science of the organization and management of farm enterprises for the purpose of securing the greatest continuous profit.” To these are added the social and economic problems of the farm and the farm home.

Farm management is the latest addition to our division of agriculture and one that promises much for farm development. Like the manufacturing enterprises, the work of the farm in this country has been revolutionized by machinery within the memory of many farmers now living. This machinery has not affected the science of farming to any great extent but it has had a wonderful effect on the business of farming. Sixty to seventy years ago one-half or more of the people were needed to produce the food and clothing

for the country. With modern farm machinery effectively used, one farmer can produce enough raw material to feed and clothe three to five other families. This calls for a new business adjustment not alone of the farm and the farmer but of the country as a whole. The farmer, while feeling the pressure, has not adjusted his work to the new conditions as readily as the manufacturer and the business man.

Up to within the past ten years no careful, scientific and comprehensive studies had been made of the subject, but the results of recent studies made in some eastern states indicate that a thorough knowledge of farm management may be worth more to the farmer than many other kinds of agricultural knowledge. Studies of this nature will be of particular value under new farm conditions in this State.

A further improvement in the organization of the Division of Agriculture of the College followed when, during the past summer, the Director was made Dean of this division, thus uniting all of the agricultural work of the institution under one head. Following this a department of agricultural extension was organized. This department will have charge of all the educational work carried on by the College out over the State.

THE WORK AND GROWTH OF THE DEPARTMENTS

The growth of the Experiment Station during the past ten years has been a growth of the various departments more largely than an addition of new departments. Veterinary science, one of the first departments started in the Station, but discontinued, has again been organized, and the poultry work has been raised to a department.

Agronomy Department.—The largest extension of the work has been in the agronomy department, due largely to the soil and crop problems of the dry farm. Experiments and observation have shown what are good and safe methods of soil-handling. They have also pointed out many of the crops and cropping methods adapted to the various sections of the State. It has been shown that the fall-wheat area is not confined to a few favored localities but makes up a belt over 300 miles wide east of and parallel to the Rocky Mountain divide. It has been shown that corn is a successful crop over all

the eastern part of the State on the dry land, particularly in districts less than 3,500 feet above sea level. Flax has been demonstrated as a successful new land crop over a very large area of the State as has also the particular advantage of such early crops as Hulless barley, and Sixty-day and Kherson oats. Alfalfa has also been grown successfully over much of the bench-land of the State.

During the past eight years, four bulletins and six circulars have been published on dry-farm methods and crops, some of these in editions as large as 40,000 copies. It is worthy of note that so great has been the demand for these bulletins and circulars that the editions of nearly all of them are exhausted, making necessary the early issue of other publications on the same subjects.

The department has now in progress a large number of experiments both at the home station and at substations over the State, looking to improved methods of soil and crop management and to the breeding and selection of improved varieties of grain better adapted to Montana conditions.

This department has also had charge of the Station irrigation studies. Early work in irrigation by the Station was mainly concerned with seepage losses from canals and gathering facts as to the actual use of water by the farmers. Later, studies were made of controlling and correcting the evils of seepage by means of drainage. During all this time careful studies have been made as to the most efficient use of water or how to get the largest possible returns from the water used. During the past few years the work has been enlarged and apparatus devised for more accurate study of all the conditions affecting the efficient use of water. Plans are now being laid to test under field conditions some of the information gained through the laboratory studies.

Irrigation development has brought two lines of work to investigators,—one distinctly agricultural and the other largely engineering, though for both specialties some understanding of the other man's problem is necessary for the best work.

The construction of the large irrigation ditch is distinctly an engineering problem. Given sufficient funds an engineer of experience will in a few years construct the works. A few years more may be necessary to correct the defects that arise from use. After

this the problem is merely maintenance while in use. The yearly cost of such maintenance will vary with the character of the construction, particularly of the headgate, flumes, turnouts, etc. If these structures are temporary they have frequently to be replaced; if permanent, the cost is generally small.

The problem of the Experiment Station commences when the settlers start to farm the lands under this ditch. There is yet work for the engineer in maintaining and protecting the canal and correcting faulty construction. There are also problems growing out of leakage from the canal and from excessive or injudicious use of water, viz, the control of seepage and the drainage of water-logged soils. There are also many engineering problems growing out of the methods of distribution of water to the farms,—lateral ditches, headgates, turnouts, water measuring devices, etc.

Not all farm irrigation problems, however, concern themselves with the large ditch. Pumping water for irrigation presents many engineering questions for the individual farmer, particularly the kind and size of the plant and the kind of power to use. In many parts of the dry-farm country concrete information is needed on the construction of small, inexpensive reservoirs to catch the run-off from the spring freshets and of diversion dams to turn the flood waters onto the farm lands where they may be used rather than permit them to run to waste down the coulees.

While the irrigation engineer's problem is to make available and get to the farm land the maximum amount of water at the minimum cost of time, money and trouble, and to prevent or overcome some of the troubles that arise through this process, the farmer's irrigation problem is to get the largest possible crop returns from this water. He wants to know what is the effect of the amount of water, the time and method of its application, and the temperature of the water or its quality upon the amount, growth, and quality or composition of the different kinds of crops he grows. With the further development of irrigation he will want to know how best to conserve the irrigation water so as to get the largest benefit from that which comes to him. This involves studies of soil and soil cultivation and of the kinds of crops which will give a proper seasonal use of the water. This farm irrigation problem has in the Montana

Station been a part of the work of the agronomy department. For the farmer, water is not an end but a means to an end—the crop. This phase of our irrigation studies we plan to make as prominent in the work of the future as it has been in the past. In extending the irrigation studies it is planned to put more emphasis on the engineering problem,—that side which is concerned in getting the water to the farm with a minimum of loss, trouble, and expense, while preventing or correcting the evils that may follow from its injudicious use.

The legislature of 1913 added materially to the responsibilities of the agronomy department by providing for the equipment and maintenance of a grain laboratory. This equipment adds greatly to the ability of the department to serve the people of the State; first, in providing facilities for testing the purity and germination of agricultural seeds; and, second, in making it possible to test the baking qualities of flour made from Montana wheats.

An additional line of work taken up in this department during the year was the farm management studies. This is a study of the business side of farming and the factors that make for success or failure in carrying on the farm business. There is room for large expansion in this work as soon as sufficient funds can be provided.

To carry on the work above outlined has called for a large increase in the personnel of the agronomy department. Ten years ago but a portion of the time of one man was given to this work. Now practically all the time of eight men is fully employed, not counting student assistants and laborers. The work has been spread over the State to enable the department to study soil and crop conditions under the great variations in climate found in different parts of Montana. The department is at present well organized for efficient service for the State and has a large number of investigations in hand.

Horticulture Department.—This department concerns itself with the growth and management of ornamental trees and shrubs, fruits, both tree and bush, and vegetables of all kinds. While every farmer is interested in all phases of this work, in a new country, trees, fruits, and vegetables occupy a secondary place to the large staples, like grain and forage crops, studied by the agronomy department. They

must also, of necessity, occupy a secondary place as to time of starting their production except in a few localities especially adapted to fruit growing.

The department made an early start in testing a great variety of ornamental trees and shrubs and of fruits adapted to Montana conditions, particularly in the higher valleys. Orchard surveys made in the fruit sections, where many scores of varieties have been grown, have pointed out the varieties adapted to these peculiar conditions.

The horticultural substation in the Bitter Root Valley, where the orchards are just coming into bearing, is giving more exact information as to varieties and methods of cultivation best adapted to this fruit section of the State. It is planned to extend this work to other substations in various parts of the State which have a different climate and soil. Only from such local studies will we be able to determine the varieties best adapted to any particular locality.

The work with vegetables has, as yet, been largely confined to the home station at Bozeman. Our problem is to find the varieties, and the methods of growing them, that will give good results in our higher valleys. Some interesting and valuable results have been obtained, reports of which will soon be published. As soon as funds will permit, this work must also be extended to the substations.

This department has also grown, but not to the extent of some others. Ten years ago the work was in charge of an assistant in the agricultural department. Now it is a full department and two men give all their time to the work.

Animal Husbandry Department.—Montana has always been a great live stock State. First were the buffaloes which roamed in countless thousands over her rolling plains and mountain valleys. A little over thirty years ago they practically disappeared. They were followed by thousands of cattle and millions of sheep, which traveled at will over the country, growing and fattening on the rich native pasture; but the time of the passing of the open range is also at hand. A new live stock era is being ushered in, and that live stock development which is beginning will be as superior to that which is just closing, in its service to man, as that was to the primitive buffalo. The live stock industry will be no longer speculative and

at the mercy of the uncertainties of the weather, but will be a safe constructive business. The growing of feed will not be left to the caprice of nature, but will be under man's guiding care. The animals will not be left at the mercy of the fierce storms of the prairie, but will have the shelter which their value and service demands. In a state where two-thirds the area will always be range, thousands of beef cattle and millions of sheep will continue to be produced under the new farm conditions, but the bands will be smaller and the owners multiplied many times. However, we must learn some lessons from the past and do all we can to reduce the labor cost for feed and care to a minimum. For the best profit the animals must still gather the larger portion of their feed both summer and winter. The risk of loss must be eliminated, however, by making readily accessible an abundance of roughage for the winter months. But the new era is going to add to our live stock thousands of dairy cows and millions of hogs and chickens. Already a large beginning has been made and the next few years will multiply it many fold.

The coming of the thousands of new settlers who have spread themselves over much of the former range country has not changed the climatic conditions, which made this country the home of the buffalo and enabled the range live stock to thrive and enrich their owners, even though no food or shelter was provided except such as the country naturally afforded,—enriched them even though a "bad" winter every six or eight years destroyed the cattle and sheep by thousands. The settler over the range has made it a better live stock country than it ever was, as he can eliminate the winter losses by providing winter feed and shelter. Moreover observation leads to the conclusion that permanent success for the Montana farmer on the irrigated, and more especially on the dry, farm can come only through a new live stock industry. Wonderfully rich and fertile as the soils of the State are, the present crop returns can be maintained for but a few years without a diversity of crops and the feeding of the most of them, roughage and also concentrates, on the farm.

The work of the animal husbandry department for the past ten years has been largely preparation for the new live stock era which is upon us. A commodious and well equipped group of live stock buildings has been erected; a large herd of dairy cows, both pure-

bred and grade, has been built up; a herd of pure-bred and grade beef cattle has been started; a large flock of several breeds of sheep is maintained; three or four breeds of hogs are kept and large numbers sold as breeders or as pork each year; and finally some three to four hundred laying hens are producing eggs nearly the year around. Practically all the hay, grain, and pasture produced on a farm of 900 acres goes to market as live stock or live stock products. A large number of experiments has been carried on with all these classes of live stock and yet more extensive tests are planned for the immediate future. A well equipped dairy provides for the testing of all milk from the cows and the manufacture of the milk into butter or cheese.

Five years ago the legislature provided for the registration, inspection and licensing of all stallions and jacks kept for service in the State, or imported to the State for such purpose. The head of the animal husbandry department was made secretary of this board and its work is carried on under his direction.

Ten years ago the animal husbandry work was all under the direction of the agriculturist who could give to it but a portion of his time. Now five men find employment in the department, four of them giving most of their time to Experiment Station work. The department is at present organized in three main divisions; animal husbandry, or the production of live stock and live stock products; dairying, or the care and manufacture of milk and its products; and poultry husbandry. Specialists are in charge of each of these lines of work. The observation, experience and experiments of the past ten years, coupled with the thorough equipment of the department, put it in a position to be of large service to the State in the coming new live stock development.

Biology Department.—To most people the problems of production appear to be the ones that trouble the farmer and while they undoubtedly occupy the major portion of his time and attention there are at times other problems that seriously worry him and interfere with his profits. From the fact that they are outside of his regular line of thought and work, they are generally hard to understand and control. For this reason also they occupy a large place in the work of the Experiment Station. Successful agriculture

demands not alone that we know how to grow crops and animals successfully but also how to protect them from disease and pests that may frequently seriously impair, and sometimes totally destroy, the profits of the farmer. While all classes of plants and animals are subject to such damage, the fruit crop seems to be especially exposed to danger. So important are protective measures for this crop that in the older fruit sections profitable fruit production is impossible without a constant fight against disease and insect pests. It would seem, too, to be a never ending fight. Old pests take on new or more virulent qualities in a new environment and with the free and rapid movement of merchandise from all parts of the earth, new pests are being continually introduced and in the new environment sometimes take on such vitality and destructiveness as to become almost a plague.

The entomologist and the bacteriologist of the biology department find in this new country an ever increasing demand upon their time and thought. Only a few years ago the fruit sections of the State were practically free from such pests as the codling moth, the apple blight, the apple scab, etc., but with the settling of the country and the great increase in the number and distribution of the orchards these and other pests are multiplying and spreading, and a persistent effort must be put forth to restrict the infected districts or to reduce the ravages to a minimum. Experiments by the biologists, supplementing the studies made in other districts, outline the methods which fruit growers must use to control these pests and diseases. The same problem is coming to us in our grain, forage crops, and roots as these crops increase and multiply over the State.

There are, too, many local pests which in the past lived upon the native vegetation, but find in our cultivated crops a more toothsome food supply or, as in the case of the spotted fever tick, become a menace because civilized man has invaded their natural habitat and thus exposed himself to infection.

The biology department has been vigilant in keeping track of every serious introduction of new insect pests or plant diseases and, to the limit of the time available and of the funds at its disposal, has worked out methods of eradication or control. The problem, however, is beyond their best endeavors, because time as well as workers

is necessary to the solution of many of the problems.

The State recognized the importance of quick attention to some of those dangers to the farmers' crops and some years ago made the entomologist of the Experiment Station, State entomologist, and appropriated about \$250 per year for traveling expenses. This sum has been gradually increased until the last legislature gave \$2,000 per year for the expense of this work over the State. The same legislature created a board of entomology of which the Station entomologist is a member. The duties of this board are to investigate and study the dissemination by insects of diseases among persons and animals, said investigations having for their purpose the eradication and prevention of such diseases. The immediate object of creating this board was to provide for the eradication of the Rocky Mountain spotted fever tick.

Another bill passed by the legislature made the Station entomologist a member of the advisory quarantine board, whose duties are to prevent the introduction and spread of insect pests and diseases of horticultural and agricultural plants.

The biology department is among the oldest in the Experiment Station and its head has had the longest continuous service of any person at present in the employ of the Station. Ten years ago there were but two men in the department. At present there are six, and four of them give the whole or a large part of their time to investigational work.

Veterinary Department.—The veterinary department has to do for the live stock on the farm what the biology department has to do for the plants, viz, to study and devise methods of controlling the diseases that affect the health of our domestic animals.

Veterinary science was among the first lines of work taken up by the Experiment Station, but was later discontinued. It was again taken up some four years ago. The department is not large but is well equipped for work. It will need considerable expansion to fully serve the people in the large and new development of the live stock industry that is beginning in the State. At present but one man is engaged in this department.

Chemistry Department.—The chemistry department occupies rather a unique position in that it is in many ways the partner of all

other departments and much of its work is carried on in cooperation with those departments. Its work is to develop our understanding of the chemical processes going on in the plant and the animal during their growth and development, to study the changes taking place in plants during the process of curing for the use of animals or during their digestion by these animals. Another large part of the work has to do with the soils, explaining the reason for variations in soil fertility and aiding in devising methods for overcoming soil sterility.

The chemistry department has also been a large factor in the agricultural development of the State, particularly in the sugar beet industry. The studies made by the United States Department seemed to indicate that Montana was outside the successful sugar beet area of the country. The investigations made by the chemistry department in a large number of irrigated valleys showed conclusively that sugar beets could be made a profitable crop in many parts of Montana. These studies were important factors in directing the attention of those interested in beet sugar manufacturing to Montana's possibilities, which ultimately resulted in the erection of a factory at Billings.

In many sections of the State, particularly in some of the irrigated valleys, there is a concentration of soluble salts in the soil, known as alkali. This concentration of salts in the soil is injurious to plant growth and it has also been found to be destructive of cement structures. The chemistry department has determined the cause of this action on cement and suggested a method of prevention.

Another activity of this department has been to keep the weather records for the local weather station. A yearly summary of these observations is given in the annual reports of the Experiment Station. The department has been making a comprehensive study of the weather reports from all over the State where records have been kept and is preparing the results for a bulletin to be issued in the near future.

The development of the Experiment Station in all departments has made necessary the enlargement of the staff of expert chemists. This was one of the first departments organized in the Experiment Station and ten years ago used part time of two men. Now four men give all their time to the work of this department and the

increasing demands for help will soon make necessary the employment of additional workers.

COOPERATION

The Experiment Station has been particularly fortunate in obtaining outside aid for its work. The earliest illustration of this was in funds given by the Irrigation Division of the United States Department of Agriculture for irrigation studies. With a few intermissions, help from this source has been continued to the present time. In the aggregate, several thousand dollars have been contributed.

The starting by the Station of dry farming studies some nine years ago was due to the help offered by Mr. Thomas Cooper of the Northern Pacific railway. Two thousand five hundred dollars was given for the first year's work. This sum was increased until \$7,500 per year was given, or a total during seven years of \$23,500. Eight years ago the Great Northern railway contributed \$2,000 per year to these dry farming studies and this sum was maintained for four years. Later the Chicago, Milwaukee & St. Paul railway contributed about \$2,500 per year and continued this for two seasons. In addition, all these railroad companies gave free transportation over their lines for all those engaged in looking after the work.

Without these contributions it would have been impossible to commence the dry farm studies when we did or to accumulate as large a fund of information about dry farming methods and dry farm crops as is at present available.

It would be very hard to measure the benefits to the State that have come from the early inauguration of these dry farming studies through the aid given by these railroad companies. The only return asked from the Experiment Station was to find the facts, whatever they are, and publish them for the information of the people of this and other states.

As the progress of our work has demanded more comprehensive studies of various dry farming problems the Bureau of Plant Industry of the U. S. Department of Agriculture has been interested in the work in Montana and for the past five years has contributed about \$3,000 per year to aid in these studies.

At Osborn on the Huntley irrigation project the U. S. Depart-

ment of Agriculture has started an experiment farm. Part of the work is carried on above and part below the ditch. For a small contribution from the State the Experiment Station has obtained a complete record of the data gathered at this station, where some \$10,000 per year has been spent for the past three years.

Some eleven years ago scientists from outside the State became interested in a particularly fatal disease in a part of the Bitter Root Valley, known as spotted fever. The late Dr. Ricketts of Chicago University definitely pointed out the relation of the wood tick to this disease. Our entomologist took up studies of the tick in 1908. Because we lacked funds to carry on the work the Bureau of Entomology and the Biological Survey of the U. S. Department of Agriculture were interested in the problem, and for the season of 1910 two men were maintained in the field studying the life history of the tick. As a result of these subsequent studies, the life history of the tick has been practically worked out and methods have been devised for its eradication, which, it is believed, will also eliminate the disease.

Such was the faith of the U. S. Bureau of Entomology in these methods of control that about a year ago an appropriation was obtained from Congress for \$15,000 for the eradication of the tick from the infected area in the Bitter Root Valley. During the last summer the work was started and will be followed up the coming season. This great help to this section of the State was a direct result of the studies started and followed up by the Station Entomologist.

Adding up all the aid contributed for practical and scientific studies in the State during the past ten to twelve years makes a total of about \$101,500. Add to this the fact that the contributions made by the various bureaus of the U. S. Department of Agriculture will probably continue for some years, the importance of securing the U. S. Department funds for scientific work in the State is still further emphasized.

These donations have supplemented, not displaced, funds obtained from the State. In some directions they have made necessary increased State appropriations, all of which, however, has

helped immensely to add to our knowledge of Montana agriculture and to our mastery over some of her problems.

APPROPRIATIONS

The legislature of 1913 made substantial appropriations for the maintenance and extension of the Experiment Station work. The general maintenance fund was raised from \$22,500 to \$37,000, an increase of \$14,500 per year. In addition \$2,500 was given for painting and other improvements on buildings. For the farm demonstration work \$17,000 per year was appropriated, which was \$3,000 per year less than for the year 1912-13. For the maintenance of the dry-farm substation at Moccasin \$4,000 per year was given, and \$2,500 for horses, machinery, etc. For the Huntley substation \$1,000 per year and for the horticultural substation \$2,000 per year was appropriated. The total increase in appropriations for maintenance and improvements for the two years was \$18,000, or \$9,000 per year.

Two bills passed by the legislature materially increased the work and responsibility of the Experiment Station, one of these established a grain laboratory at the Station and the other provided for the testing and labeling at this laboratory of farm seeds sold in the State. An appropriation of \$2,000 was made to equip this laboratory and \$4,000 was given for the two years for maintenance.

An appropriation of \$5,000 was made for the acquiring of 2,000 acres of land and the buildings on the Fort Assinaboine military reservation near Havre, and another \$5,000 for equipping and maintaining an agricultural experiment station on the site. The appropriation, however, was contingent upon the Federal Government turning over to the State the land and buildings at the price stated. This has not yet been done.

IMPROVEMENTS AND ADDITIONS

Considerable improvements have been made on the college farm during the year. The farm buildings have been painted, a large amount of fencing has been built, brush has been cleared from the sloughs on the west farm and a beginning made in clearing up the brush on the Fort Ellis farm. Considerable ditching has also been done on the west farm and a large number of permanent culverts and headgates put in, both around and through the farm. About \$5,000 has been spent in these improvements.

THE GRAIN LABORATORY

The rooms over the lower heating plant have been fixed up for the grain laboratory. One room is used for milling tests, and a small experimental mill has been installed. It is giving very good satisfaction. Another room has been fitted up for the baking tests with sponge case, electric mixer, electric oven, and other equipment necessary to the baking of the test samples of flour. The third room is equipped for seed testing, with cleaners, samplers, germinators, etc. While more apparatus is needed to complete the equipment a very good start has been made. A man has been engaged to give his full time to this work and the demands are keeping him busy.

SUBSTATIONS

The work at the substations has progressed satisfactorily during the year. The crops at all places were good. At the dry-farm substation near Moccasin the work has been enlarged, due to the acquisition of additional land rented from the State. Much additional equipment was purchased during the year and material has been provided to fence the entire section.

The annual summer picnic at this station in the latter part of July was again very well attended. Speakers of prominence were present and addressed the people, and very great interest was manifested in the work of the station. People from all parts of the Judith Basin were in attendance and the trains brought in many from as far away as Billings and Great Falls. The railroads provided a very accommodating service. Special trains on the Great Northern started from Great Falls, from Billings and from Lewistown, all of which reached the grounds by noon or a little after and were held at Moccasin until about six o'clock to take the people home.

At the Huntley substation the work has been enlarged and systematic studies have been undertaken on the dry land as well as on that which is irrigated. Some interesting and valuable data have been gathered at this place but it is too early yet to report results.

The horticultural substation in Ravalli County is beginning to show results. The trees are coming into bearing and the effects of different methods of cultivation and management are becoming apparent. From this time on we will be able to make thorough studies of the varieties under observation.

In the plans submitted to the last legislature three additional substations were recommended; one of these to be located west of the Rocky Mountain divide, probably in the Flathead Indian reservation; one in the northern part of the State on the Fort Assinaboine military reservation; and one in the eastern part of the State, where corn promises to be an important crop, while other crops are not as successful as in the western part of the State. These stations, it is believed, with those already established, would fairly well cover the various climatic regions of the State. The legislature acted on but one of these recommendations. A substation was established on the Fort Assinaboine military reservation contingent upon the Federal Government turning over the land and buildings to the State. As this has not been done no work has been undertaken at this place during the year.

DEMONSTRATION FARMS

In accordance with plans submitted to the legislature one year ago, we have during the year closed up the work on several demonstration farms in various parts of the State. But four or five will be conducted during the coming year. These demonstration farms have served a very useful place in our study of the agriculture of the State, but they now give place to better methods. A detailed report of the results of the work will be prepared next year.

AGRICULTURAL EXTENSION SERVICE

At the last session of the legislature a bill was passed making it possible for the county commissioners in any county of the State to appropriate \$100 per month toward the salary and expenses of a county agricultural instructor. The bill also provides that the instructor shall be nominated by and be under the direction of the director of the Experiment Station or such agent or agents as he shall name.

The county support coupled with the funds available from the demonstration farm work enabled us last year to maintain two county men in the field, one in Fergus County and another in Custer County. During the coming year it is planned to still further extend this county work as the experience of the past year clearly demonstrated the value of those county men as helpful factors in building up the

agriculture of the districts where they are located.

To make the work more effective a department of agricultural extension has been organized with F. S. Cooley, superintendent of Farmers' Institutes, in charge. All of the educational work in agriculture and home science carried on by the College out over the State will be under the direction of this department.

In addition to the county men, who in a measure will be general agriculturists and confine their work to one county, it is planned to employ State workers who will be specialists in some field of agriculture, as agronomy, animal husbandry, horticulture, etc., or in the field of home economics. These State workers will help on special problems that come to the county agriculturists and also help at farm meetings in various parts of the State. At the beginning the State workers will also have charge of some of the special departments of the extension service as assistants to the superintendent of extension.

The organization as above outlined will make for economy and efficiency in carrying on this field educational work, and we hope make more available to the people of the State the results obtained by the Experiment Station.

Another phase of the extension work may be termed publicity, giving to the press and people of the State early reports on the results of the experimental work of our own and neighboring states, and answering the large number of requests for information that come to us from all parts of the State. For several months during the past year systematic efforts have been made to supply the papers of the State with short articles on some timely agricultural topic.

About 500 words a week has been sent to all the papers of the State and about 6,000 words per week of special agricultural matter has been prepared.

CORRESPONDENCE

The correspondence is largely handled by the various departments. The demands in this direction are growing very rapidly. During the past year over 15,000 letters were received and answered. About 5,500 of these were requests for bulletins and were answered by a card and the sending of the bulletins and circulars. Special inquiries for information have been answered by the departments.

The agronomy department has had the largest demand on its time and thought, 3,500 letters having been answered during the year. The other departemnts have answered letters as follows: animal husbandry, 1,000; biology, 1,390; chemistry, 500; horticulture, 800; poultry, 425; veterinary science, 420; and office, 1,500.

The largest proportion of the demands for information come during the winter season. This increase in correspondence is getting to be quite a tax on some of the departments and it is hoped that the extension department will relieve them of it in the near future.

Probably the increase in correspondence and work of the Station may also be shown by the increased demands for clerical help. Ten years ago but \$300 per year was paid out for office help, but a part of the time of a student being used. Now seven office assistants are employed at a cost close to \$4,500 per year and this help will soon have to be increased.

MAILING LIST

The Station mailing list continues to grow. We are now publishing an edition of 14,000 of each bulletin for general distribution and 12,000 of each circular for distribution in the State. The names on the mailing list number 12,365, distributed as follows: Montana 6,750, other colleges and stations 3,075, other states 1,680, foreign countries 240, libraries 348, and newspapers 270.

In addition to the names on the regular mailing list over 5,500 requests came for special bulletins and in answer to such requests about 16,500 bulletins and circulars were sent out during the year.

Any person in Montana who would like to receive the bulletins and circulars regularly may have his name placed on the permanent mailing list to receive them as issued. They are sent free of cost. These publications are not issued at any regular periods but are distributed at irregular intervals as received from the press. Names are not put on the regular mailing list except on special request. In other words we do not consider a request for a certain bulletin as a request to go on the permanent mailing list. Copies of the bulletins and circulars as issued are sent to all newspapers in the State and to all public libraries. The newspapers can thus give early notice of the availability of the bulletins and the libraries will have them for the use and reference of their patrons. The most of the

earlier bulletins of the Experiment Station are out of print and it is only through the libraries that they are available for study.

THE WORK OF THE EXPERIMENT STATION COVERS THE STATE

The work of the Experiment Station is not confined to Bozeman. This is well illustrated by the accompanying map, which shows where the agronomy and horticulture departments have carried on demonstrations or experiments during the past ten years. The results of this work have given much valuable information about the crop possibilities of nearly all sections of the State.

The work of the biology department is not confined to any particular farm, but is carried on in the various fruit sections of the State, particularly in Ravalli, Missoula, Sanders, Flathead, Yellowstone, and Carbon Counties. In the study of insects that affect the field crops, all parts of the State are visited.

The chemistry department, in the sugar beet studies, carried on work in nearly all the irrigated valleys of the State, and in the studies of infertile soils is making investigations on soils from many parts of the State, both above and below the ditch.

The location of the permanent substations, in operation or proposed, shows that these stations will fairly well cover the various climatic regions of the State. Corvallis and Ronan are west of the Rocky Mountain divide, Havre is in the northern part of the State, Moccasin in the central part, Huntley in the southern part, and Fallon in the eastern part of the State.

In Ravalli County, near Corvallis, is the horticultural substation, which is devoted wholly to experiments with fruits of various kinds. The five other substations in operation or proposed will also take up studies with fruit and ornamental trees and shrubs. The main work of these stations, however, will be to study the kinds and varieties of crops and the different cropping methods that will give best results under the peculiar climatic conditions there prevalent. It is believed that these stations cover fairly well, though in a broad way, the various climatic regions of the State, and for many years to come no other substations should be established.

AT THE HUNTLEY SUBSTATION

Forage crop studies under irrigation.

Grain investigations under irrigation.

Growing flax under irrigation.

Dry farm rotation studies.

AT HORTICULTURAL SUBSTATION

Variety tests of commercial fruits.

Orchard cultural tests.

PUBLICATIONS OF THE YEAR

Bulletin No. 93. "Fergus County Substation Report on the Work and Plans," by John M. Stephens, superintendent of Substation. This bulletin was prepared to give a somewhat comprehensive statement of the work undertaken and carried on at this station, rather than to give any special conclusions on the results of the work.

Bulletin No. 94. "Clover and Corn Silage as Feed for Dairy Cows," by Prof. R. W. Clark. This bulletin records the results of four experiments in feeding clover and corn silage as compared with clover hay as a feed for cows.

Bulletin No. 95. "Horse Feeding Experiments," by Prof. R. W. Clark. This is a record of test showing the advantage of feeding a limited hay ration to work horses.

Bulletin No. 96. "A Contribution to Our Knowledge of Apple Scab," by H. E. Morris. This is a history of the spread of this disease in Montana, a discussion of its characteristics and methods of control. A bibliography of publications dealing with the disease is also given. One colored plate.

Bulletin No. 97. "Farm Management in the Gallatin Valley," by E. L. Currier. This is a report of farm management studies made in the Gallatin Valley during the summer of 1913. The returns from some fifty farms in one township are tabulated and discussed.

Bulletin No. 98. "Eleventh Annual Report of the State Entomologist," by Prof. R. A. Cooley. This is a report on the new insects observed during the year, and comments on others that have been troublesome in various parts of the State.

"The Twentieth Annual Report" of the Experiment Station. This report sums up the growth of the Montana Experiment Station

for the first twenty years of its work. A complete list of the bulletins and circulars published to date is given, also a list of the projects at present on hand.

Circular 27. "Cooperation for Better Farming," by Prof. F. S. Cooley, suggests a plan for farm cooperation.

Circular 28. "The Imported Cabbage Worm and the Cabbage Aphis," by J. R. Parker, gives a description of these cabbage pests and methods for their control. Twelve illustrations.

Circular 29. "Irrigation Practice in Montana," by H. B. Bonbright, deals with methods of leveling land, with running ditches, and with spreading irrigation water over the land. Thirty-two illustrations.

Circular 30. "The State Grain Laboratory and the Montana Seed Laws," by Prof. A. Atkinson and B. W. Whitlock, gives a copy of the laws establishing the laboratory, defines its work, and gives rules and regulations governing the labeling of seed and grain samples to be tested at the grain laboratory.

Circular 31. "Care and Management of Sheep on the Farm," by R. F. Miller. This was prepared to help Montana farmers in the care of their home flocks.

Circular 32. "Farm Butter-Making and the Creamery Industry in Montana," by R. C. Jones. Methods are outlined for the making of good butter on the farm and plans given on how to organize and build a community creamery. Twenty illustrations.

Circular 33. "Hog Cholera in Montana," by Dr. W. J. Taylor, describes the symptoms of this disease and the methods recommended for its control. Seven illustrations.

Circular 34. "Artificial Hatching of Chicks," by Prof. W. F. Schoppe, gives some of the more essential points to be considered in selecting and operating an incubator for hatching chicks. Five illustrations.

Circular 35. "The Alfalfa Weevil," by Prof. R. A. Cooley, calls attention to this serious pest occurring in neighboring states and warns the Montana farmer to be on the lookout against its introduction. Nine illustrations.

Circular 36. "Fungicides and Insecticides," by H. E. Morris and J. R. Parker, gives directions for the preparation and use of various

Feeding value of clover cut at various stages of growth.

Advantage of feeding soiling crops to dairy cows.

What is the most profitable kind and amount of grain to feed to dairy cows, with a basic ration of ensilage or clover or alfalfa hay?

Effect of kinds of feed and management on sows and their litters.

Effect of feeding pigs two, three, and five times a day.

Value of milk and pasture with the grain ration in fattening hogs.

Value of soaked, compared with unsoaked, food for hogs.

Value of clover silage in beef production.

Effect of methods of soil and crop management on the moisture and nitrates of the soil. (This test carried out on the dry farm).

Tests of various crop rotations.

Variety tests of grain and forage crops. (Nearly all kinds of grain and forage crops adapted to this locality are grown).

Alfalfa tests. (Many varieties are under observation.)

What is the best time in the spring or fall to seed different kinds of grain?

What ratio of seeding for various kinds of grain gives the largest crops?

Irrigation tests: amount of water and time applied to get the best crop.

Cooperative grain tests: to study the effect on the crop of using seed grain produced in other states under different climatic conditions.

Tests of variation in soil of a field used for grain tests and how to get correct comparisons from such varying soil.

Tank experiments on duty of water and evaporation losses from soils in Montana.

Effect of deep tillage on the dry land.

Effect of deep tillage on the irrigated land.

Test of single and double disk drills.

Correlation studies with plants.

Relation of water losses from soil in tanks to dry weight of crop grown on such soil.

Effect of applying water at different times to crops.

Effect of phosphorus fertilizer on grain yields.

The life history and methods of controlling insect pests affecting the sugar beet.

Bark and wood diseases of apple trees.

The effect of arsenic on vegetation.

Methods of controlling the oyster-shell scale.

Insect survey of Montana.

The Rocky Mountain spotted fever tick: its life history and methods of control.

The little potato disease: its cause and prevention.

Fungus disease of the plum: its cause and control.

Incubation of eggs: a study of the conditions necessary to the successful hatching of chicks under the hen or in the incubator.

Chemical study of the composition of clover cut at various stages of growth.

Chemical study of the changes taking place in clover silage.

Study of Montana's infertile soils.

Study on poultry feeding and management under Montana conditions.

The effect of hopper as compared with litter feeding of poultry.

Tests of varieties of small fruits.

Tests of varieties of vegetables.

Tests of ornamental trees and shrubs.

Tests of tree fruits.

Studies on the healing of pruning wounds.

Studies on the results of thinning apples.

Varieties and cultural tests with potatoes.

Studies on contagious abortion among cattle.

The effect of feeding milk treated with formalin to calves.

The cause and methods of transmission of infectious anemia in horses.

Studies on Hog Cholera.

AT THE DRY-FARM SUBSTATION, FERGUS COUNTY

Test of grain varieties on the dry farm.

Tests of effects of methods of cultivation on crop yield on the dry farm.

Experiments with different rotations adapted to the dry farm.

Effect of subsoiling by dynamite on the dry farm.

AT THE HUNTLEY SUBSTATION

Forage crop studies under irrigation.
Grain investigations under irrigation.
Growing flax under irrigation.
Dry farm rotation studies.

AT HORTICULTURAL SUBSTATION

Variety tests of commercial fruits.
Orchard cultural tests.

PUBLICATIONS OF THE YEAR

Bulletin No. 93. "Fergus County Substation Report on the Work and Plans," by John M. Stephens, superintendent of Substation. This bulletin was prepared to give a somewhat comprehensive statement of the work undertaken and carried on at this station, rather than to give any special conclusions on the results of the work.

Bulletin No. 94. "Clover and Corn Silage as Feed for Dairy Cows," by Prof. R. W. Clark. This bulletin records the results of four experiments in feeding clover and corn silage as compared with clover hay as a feed for cows.

Bulletin No. 95. "Horse Feeding Experiments," by Prof. R. W. Clark. This is a record of test showing the advantage of feeding a limited hay ration to work horses.

Bulletin No. 96. "A Contribution to Our Knowledge of Apple Scab," by H. E. Morris. This is a history of the spread of this disease in Montana, a discussion of its characteristics and methods of control. A bibliography of publications dealing with the disease is also given. One colored plate.

Bulletin No. 97. "Farm Management in the Gallatin Valley," by E. L. Currier. This is a report of farm management studies made in the Gallatin Valley during the summer of 1913. The returns from some fifty farms in one township are tabulated and discussed.

Bulletin No. 98. "Eleventh Annual Report of the State Entomologist," by Prof. R. A. Cooley. This is a report on the new insects observed during the year, and comments on others that have been troublesome in various parts of the State.

"The Twentieth Annual Report" of the Experiment Station. This report sums up the growth of the Montana Experiment Station

for the first twenty years of its work. A complete list of the bulletins and circulars published to date is given, also a list of the projects at present on hand.

Circular 27. "Cooperation for Better Farming," by Prof. F. S. Cooley, suggests a plan for farm cooperation.

Circular 28. "The Imported Cabbage Worm and the Cabbage Aphis," by J. R. Parker, gives a description of these cabbage pests and methods for their control. Twelve illustrations.

Circular 29. "Irrigation Practice in Montana," by H. B. Bonbright, deals with methods of leveling land, with running ditches, and with spreading irrigation water over the land. Thirty-two illustrations.

Circular 30. "The State Grain Laboratory and the Montana Seed Laws," by Prof. A. Atkinson and B. W. Whitlock, gives a copy of the laws establishing the laboratory, defines its work, and gives rules and regulations governing the labeling of seed and grain samples to be tested at the grain laboratory.

Circular 31. "Care and Management of Sheep on the Farm," by R. F. Miller. This was prepared to help Montana farmers in the care of their home flocks.

Circular 32. "Farm Butter-Making and the Creamery Industry in Montana," by R. C. Jones. Methods are outlined for the making of good butter on the farm and plans given on how to organize and build a community creamery. Twenty illustrations.

Circular 33. "Hog Cholera in Montana," by Dr. W. J. Taylor, describes the symptoms of this disease and the methods recommended for its control. Seven illustrations.

Circular 34. "Artificial Hatching of Chicks," by Prof. W. F. Schoppe, gives some of the more essential points to be considered in selecting and operating an incubator for hatching chicks. Five illustrations.

Circular 35. "The Alfalfa Weevil," by Prof. R. A. Cooley, calls attention to this serious pest occurring in neighboring states and warns the Montana farmer to be on the lookout against its introduction. Nine illustrations.

Circular 36. "Fungicides and Insecticides," by H. E. Morris and J. R. Parker, gives directions for the preparation and use of various

fungicides and insecticides in controlling plant diseases and insect pests of the farm and orchard. Four illustrations.

Circular 37. "Fruit Diseases in Montana," by Prof. Deane B. Swingle, presents a full discussion of the diseases affecting fruit in various parts of the State and gives methods for prevention or control. One colored plate, 21 illustrations.

Six bulletins, fifteen circulars and the twentieth annual report make up the publications of the year. The following table gives some facts about these publications:

BULLETINS

No.	Edition	Pages	Total pages
93	7,000	32	234,000
94	13,000	22	286,000
95	13,000	10	130,000
96	5,000	38	190,000
97	14,000	18	152,000
98	6,000	20	120,000
20th Annual Report	15,000	48	720,000
Total.....	72,000	188	1,832,000

CIRCULARS

No.	Edition	Pages	Total pages
27	3,000	8	24,000
28	14,000	16	284,000
29	13,000	48	576,000
30	12,000	16	192,000
31	12,000	24	288,000
32	12,000	40	480,000
33	12,000	16	192,000
34	12,000	22	264,000
35	12,000	16	192,000
36	12,000	56	672,000
37	6,000	68	408,000
Special 1	3,000	9	27,000
Special 2	8,000	23	184,000
Total.....	130,000	362	3,783,000

Special Circular 1 gives a list of the recognized breeds of pure-bred live stock in the country, for the information of the assessors of the State.

Special Circular 2 gives a list of the breeders of pure-bred live stock in Montana, as gathered by the county assessors.

Extension leaflets. To answer as comprehensively as possible the many inquiries for information coming to the Station, a large number of leaflets have been prepared. These are not sent to any regular mailing list, but only in answer to letters of inquiry. A limited edition only is printed, 1,000 to 2,000 copies. The following is a list of topics. Instructions for sending Insect Pests and Diseased Plants to the Experiment Station; Clothes Moths; Oyster-Shell Scale; Cabbage Worms and Lice; The Pea-Weevil, a Warning; Grasshopper Control; The Alfalfa Leaf Weevil, a Warning; Ants; Poultry Lice and Mites; The Green Apple Aphis; The Colorado Potato Beetle; Treatment of Seed for Grain Smuts; Potato Diseases; Apple Scab; Crown Gall; Canada Thistle; The Weed Problem; Alfalfa Dodders; The Wild Mustards; The Preparation of Insecticides and Fungicides; and The Dry-Farm Seed Bed.

COMPLETE LIST OF STATION PUBLICATIONS FROM ORGANIZATION OF STATION IN 1893

The bulletins and circulars marked* are out of print. Those not so marked are yet available for distribution and will be sent to any person who applies, as long as the supply lasts.

BULLETINS

No.

1. Organization—Announcements.
- *2. Smuts of Wheat, Oats and Barley.
- *3. Pig Feeding.
- *4. Glanders.
- *5. First Annual Report—Crop Statistics of Gallatin County.
- *6. Measurement of Water.
- *7. Small Grains and Potatoes.
- *8. Second Annual Report—Crop Statistics of Gallatin County,
Parasitic Ictero—Herimaturia of Sheep.
- *9. Potatoes.

LIST OF STATION PUBLICATIONS (Continued)

No.

- *10. Small Grains; Wheat, Oats, Barley.
- *11. Devices for Obtaining a Constant Flow in Laterals with Variable Heads in the Main Canals or Reservoirs.
- *12. Third Annual Report—Spaying of Mares.
- *13. Drinking Water.
- *14. Montana Swine Feeding.
- *15. Larkspur Poisoning of Sheep.
- *16. Fourth Annual Report.
- *17. The Grain Aphis—An Army Cut Worm.
- *18. The Alkali Soils of Montana.
- *19. The Sugar Beet in Montana.
- *20. Fifth Annual Report.
- *21. Sheep Feeding.
- *22. Thirteen Botanical Subjects.
- *23. Injurious Fruit Insects; Insecticides; Insecticide Apparatus.
- *24. Sixth Annual Report.
- *25. Paris Green and London Purple.
- *26. Poultry Raising.
- *27. Live Stock Feeding Tests; Beef Cattle, Lambs, and Swine.
- *28. Seventh Annual Report.
- *29. Quality of Water Used in Irrigation.
- *30. Weeds in Montana.
- *31. Report of Grazing and Feeding Tests; Beef Cattle and Lambs.
- 32. Eighth Annual Report.
- 33. Sugar Beets in Montana.
- *34. Farmers' Weirs.
- 35. Report of Feeding Tests.
- *36. Forage Conditions in Montana.
- *37. Pork Production in Montana.
- *38. Food Adulterations.
- *39. Sheep Feeding in Montana.
- *40. Root Crops in Montana.
- *41. Sugar Beets (1902).
- 42. The Codling Moth.
- Ninth Annual Report

LIST OF STATION PUBLICATIONS (Continued)

- | | |
|------|---|
| No. | |
| *43. | Duty of Water. |
| *44. | Apple Growing in Montana. |
| 45. | Loco and Some Other Poisonous Plants in Montana. |
| 46. | Two Insect Pests. |
| *47. | Sheep Feeding. |
| *48. | Steer Feeding. |
| *49. | Contagious Abortion in Montana. |
| *50. | Poultry Management and Poultry Diseases. |
| *51. | First Annual Report of the State Entomologist.
Tenth Annual Report. |
| *52. | Sugar Beets. |
| *53. | Creameries and Cheese Factories. |
| *54. | The Alkali Soils of Montana. |
| *55. | Second Annual Report of the State Entomologist.
Eleventh Annual Report. |
| *56. | Native Economic Plants of Montana. |
| *57. | Feeding Pigs. |
| *58. | Fattening Cattle. |
| *59. | Sheep Feeding. |
| *60. | Onion Culture. |
| *61. | Food Adulterations. |
| *62. | Third Annual Report of the State Entomologist.
Twelfth Annual Report. |
| *63. | Dry Farming in Montana. |
| *64. | Fourth Annual Report of the State Entomologist. |
| *65. | Seepage and Drainage. |
| *66. | Orchard Survey in the Bitter Root Valley.
Thirteenth Annual Report. |
| *67. | Practical Beekeeping. |
| *68. | Canadian Field Peas. |
| *69. | The Effect of Alkali on Portland Cement. |
| *70. | The Douglas Fir Cone Moth. |
| 71. | The Fifth Annual Report of the State Entomologist.
Fourteenth Annual Report. |
| *72. | Measurement of Water. |

LIST OF STATION PUBLICATIONS (Continued)

No.

- *73. Pig Feeding Experiments.
- *74. Dry Farming Investigations in Montana.
- *75. The Sixth Annual Report of the State Entomologist.
- *76. Seepage and Drainage.
Fifteenth Annual Report.
- *77. Fruit Tree Planting in Montana.
- *78. Steer Feeding Experiments.
- *79. The Seventh Annual Report of the State Entomologist.
Sixteenth Annual Report.
- 80. Ornamental Trees and Shrubs for Montana.
- 81. Destruction of Hydraulic Cements by the Action of Alkali Salts.
- 82. Eighth Annual Report of the State Entomologist.
- 83. Dry Farming Investigations in Montana.
- *84. Grain Investigations with Wheat, Oats and Barley.
Seventeenth Annual Report.
- *85. Tick Control in Relation to the Rocky Mountain Spotted Fever.
- *86. The Use of Soap to Retard the Settling of Certain Arsenicals.
- 87. Dry Farm Moisture Studies.
- 88. Ninth Annual Report of the State Entomologist.
Eighteenth Annual Report.
- *89. Experiments with Pigs.
- 90. Use of Carbolic Acid for Prevention of Contagious Abortion
- 91. Winter Injury to Fruit Buds of Apple and Pear.
- 92. Tenth Annual Report of the State Entomologist.
Nineteenth Annual Report.
- 93. Fergus County Substation.
- 94. Clover and Corn Silage as Feeds for Dairy Cows.
- 95. Horse Feeding Experiments.
- 96. A Contribution to Our Knowledge of Apple Scab.
- 97. Farm Management in the Gallatin Valley.
- 98. Eleventh Annual Report of the State Entomologist.
Twentieth Annual Report.

LIST OF STATION PUBLICATIONS (Continued)

No.

CIRCULARS

- *1. Home Cheesemaking.
- 2. The Pear and Apple Blight in Montana.
- 3. Dry Farming Practice in Montana.
- 4. The Army Cutworm.
- 5. Alfalfa Management in Montana.
- 6. Flax Growing in Montana.
- 7. Preliminary Report on the Analyses of Montana Waters.
- 8. The Action of Alkali on Hydraulic Cements.
- 9. Poultry Houses.
- 10. Dairying in Montana.
- 11. Navel-Ill in New-Born Foals.
- 12. A Warning Against Fan Weed.
- 13. Hog Management in Montana.
- 14. Planting Trees and Shrubs on the Dry Farm.
- *15. Flax Growing in Montana.
- 16. The Pear-Leaf Blister-Mite.
- 17. A Spraying Program for Montana Orchards.
- 18. Chick Feeding.
- *19. Suggestions to the Dry Farmer.
- 20. Control of Prairie Dogs and Ground Squirrels.
- 21. The Roller or Packer.
- 22. Cropping to Flax on New Lands of Semi-Arid Land Areas.
- *23. Creamery Organization and Management.
- 24. The Measurement of Water.
- 25. Cabbage and Cauliflower in Montana.
- 26. Celery Culture in Montana.
- 27. Cooperation for Better Farming.
- 28. Cabbage Worms and Cabbage Aphis.
- 29. Irrigation Practice in Montana.
- *20. Grain Laboratory.
- 31. Care and Management of Sheep on the Farm.
- 32. Farm Butter-Making—Creamery Industry in Montana.
- 33. Hog Cholera in Montana.

LIST OF STATION PUBLICATIONS (Continued)

No.

34. Artificial Hatching of Chicks.

35. Alfalfa Weevil.

36. Fungicides and Insecticides.

37. Fruit Diseases in Montana.

Special Circular 1. The Breeds of Pure Bred Live Stock.

Special Circular 2. A List of Breeders of Pure Bred Live Stock in
Montana.

WEATHER RECORD, BOZEMAN STATION
SUMMARY BY MONTHS FOR THE YEAR 1913

	Highest temperature	Lowest temperature	Mean temperature..	Precipitation	Clear days.....	Partly cloudy days..	Cloudy days.....	Days with 0.01 of an inch or more precipitation	Direction of prevailing winds.....
January	47	-16	20.11	.79	7	3	21	7	SW
February	54	-19	13.96	.47	10	4	14	6	SE
March	53	-12	25.67	.44	9	7	15	5	NW
April	74	20	42.61	1.65	12	5	13	7	SE
May	82	23	48.98	2.54	9	6	16	15	NW
June	80	38	58.06	3.19	3	26	1	16	NE
July	89	32	60.09	2.17	14	13	4	12	SE
August	89	37	64.29	.90	17	13	1	4	SE
September	85	19	53.98	1.90	17	10	3	11	NE
October	76	13	37.19	3.15	10	6	15	11	SW
November	60	9	34.66	1.24	14	5	11	7	SE
December	40	1	21.19	.15	18	8	5	3	SE
For the year..			40.07	18.59	140	106	119	104	

SUMMARY FOR THE YEAR 1913

Highest temperature.....89 degrees July 6th and Aug. 25th
Lowest temperature.....-19 degrees, February 7th
Greatest range.....108 degrees
Highest monthly mean.....64.29 degrees August
Lowest monthly mean.....13.9 degrees February
Highest daily mean.....76 degrees August 25th
Lowest daily mean.....-9.5 February 7th
Mean temperature for the year.....40.07
Greatest total precipitation for one month.....3.15, October
Lowest total precipitation for one month......15, December
Total rainfall.....18.59 inches
First killing frost.....September 23rd
Last killing frost.....July 14th
Number of clear days in year.....140
Number of partly clear days in year.....106
Number of cloudy days in year.....119
Days with .01 inch or more precipitation.....104

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